PhD – Thesis

Osteometric Variation of the Human Spine in Central Europe by Historic Time Period and Its Microevolutionary Implications

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Abstract

For most parts of the human body, the morphometry and its variation with regard to microevolutionary and secular trends, sexual dimorphism and individual aging are well known. Surprisingly, studies focusing on the vertebral column have so far primarily used either a macroevolutionary or a clinical focus. The aim of this study is to address the osteometry and variation of the human spine from a special perspective, possible microevolutionary alterations.

A total of 348 human skeletons, dating from 28,000 B.C. to the mid 20th century A.D., from 24 sites mostly in Switzerland and Southern Germany, and without macroscopic pathology, were measured with a caliper by a single observer. These measurements at vertebral levels cervical 3 and 7, thoracic 1, 6 and 10, and lumbar 1 and 5 were taken: ventral and dorsal vertebral body height, sagittal and transverse vertebral body and spinal canal diameters, spinous and transverse process length, pedicle height and intervertebral foramen widths; as well as the diameters of the foramen magnum, humerus and femur length and circumference, femur head breadth and bi-iliac widths.

With the exception of most of the bony outlines of the neural pathways, males show larger osteometric dimensions than females. No side difference of bilaterally measured variables was found. Variables of neighbouring vertebrae correlate to a higher extent than more distantly located variables; similar measurements at different vertebral levels correlate generally better than non-related measurements. With greater individual age, especially in males, the diameters of the vertebral body and pedicle height increase. A positive microevolutionary trend, with both increasing mean values and standard deviations, could be found; this trend was independent of stature for selected measures.

The samples show a microevolutionary increase in most of the spinal variables. Since both, mean values and standard deviations, increased, one may explain this higher intra-group variability to be a result of relaxed natural selection. Various environmental or genetic factors could explain the short-term alteration of the spinal osteometry. Furthermore, the relative smaller size and decrease with age of the bony outline of the neural pathways in males, could explain their higher vulnerability to modern lower back pathologies.

Statement

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Dr. med. Frank J. Rühli

Adelaide, 9. 6. 2003

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"May those deceased individuals, whose sleep was disturbed

driven by scientific curiosity, rest forever peacefully!"

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Introduction

Anatomical aspects of the human spine

The spine is a crucial and individually different part of the human axial skeleton. As Bohart (1929, p. 698) mentioned: "*...an individual's spinal column is as characteristic of that individual as his face...*". Similarly, Ravenel (1877) already mentioned the high degree of inter-individual variability of the human spinal dimensions.

The anatomical structure of the human spine has been studied on a macroscopic and microscopic level for many centuries. To be able to distinguish between the occurrence of an abnormality and an anatomical variation within the human vertebral column, one has essentially to conduct a precise assessment of the normal structure and its size. This assessment can be done by various approaches, either by using animal models (Iwamoto *et al.*, 1995), in clinical studies involving asymptomatic and / or symptomatic patients (Horner, 1854; Blumensaat and Clasing, 1932; Junghanns, 1933; Elsberg and Dyke, 1934; Wolf *et al.*, 1956; Epstein *et al.*, 1962; Burrows, 1963; Hurxthal, 1968; Katz *et al.*, 1975; Ramani, 1976; Porter *et al.*, 1978a; Porter *et al.*, 1978b; MacGibbon and Farfan, 1979; Larsen and Smith, 1980a; Larsen and Smith, 1980b; Porter *et al.*, 1980; Stockdale and Finlay, 1980; Ullrich *et al.*, 1980; Ogino *et al.*, 1983; Weisz and Lee, 1983; Drinkall *et al.*, 1984; Kikuchi *et al.*, 1984; Macdonald *et al.*, 1984; Nissan and Gilad, 1984; Bolender *et al.*, 1985; van Schaik *et al.*, 1985; Gilad and Nissan, 1986; Nissan and Gilad, 1986; Gallagher *et al.*, 1988; Hedlund and Gallagher, 1988; Minne *et al.*, 1988; Davies *et al.*, 1989; Black *et al.*, 1991; Hermann *et al.*, 1993; Frobin *et al.*, 1997; Humphreys *et al.*, 1998; Wildermuth *et al.*, 1998; Schmid *et al.*, 1999; Harrington *et al.*, 2001), by using cadaver material (Horner, 1854; Ravenel, 1877; Jacobi, 1927;

Larmon, 1944; Magnuson, 1944; Dommisse, 1974; Dommisse, 1975; Veleanu, 1975; Crock, 1981; Hasue *et al.*, 1983; Bose and Balasubramaniam, 1984; Kikuchi *et al.*, 1984; Rauschning, 1987; Stephens *et al.*, 1991; Yoo *et al.*, 1992; Hasegawa *et al.*, 1995; Ebraheim *et al.*, 1996; Nowicki *et al.*, 1996; Lu *et al.*, 2000; Fujiwara *et al.*, 2001; Cinotti *et al.*, 2002) or by analysing macerated bone specimens (Anderson, 1883; Thomson, 1913; Huizinga *et al.*, 1952; Epstein *et al.*, 1962; Epstein *et al.*, 1964; Dommisse, 1975; Veleanu, 1975; Eisenstein, 1977; Kikuchi *et al.*, 1977; Eisenstein, 1980; Postacchini *et al.*, 1983; Berry *et al.*, 1987; Scoles *et al.*, 1988; Lee *et al.*, 1995; Ebraheim *et al.*, 1996; Cinotti *et al.*, 2002).

The measurement of the human vertebral column has been so far defined for radiological (Elsberg and Dyke, 1934; Wolf *et al.*, 1956; Burrows, 1963; Hurxthal, 1968; Jones and Thomson, 1968; Vital *et al.*, 1983; Nissan and Gilad, 1984; Bolender *et al.*, 1985; van Schaik *et al.*, 1985; Gilad and Nissan, 1986; Nissan and Gilad, 1986; Krag *et al.*, 1988; Marchesi *et al.*, 1988; Olsewski *et al.*, 1990; Stephens *et al.*, 1991; Vaccaro *et al.*, 1995; Kothe *et al.*, 1996; Karaikovic *et al.*, 1997; Schmid *et al.*, 1999; Harrington *et al.*, 2001; Kandziora *et al.*, 2001) or osteometric studies (Horner, 1854; Aeby, 1879; Anderson, 1883; Rosenberg, 1899; Wetzel, 1910; Hasebe, 1913; Thomson, 1913; Cyriax, 1920; Stefko, 1926; Jacobi, 1927; Martin, 1928; Huizinga *et al.*, 1952; Veleanu, 1972; Veleanu, 1975; Saillant, 1976; Kikuchi *et al.*, 1977; Putz, 1981; Postacchini *et al.*, 1983; Larsen, 1985; Cotterill *et al.*, 1986; Berry *et al.*, 1987; Marchesi *et al.*, 1988; Scoles *et al.*, 1988; Olsewski *et al.*, 1990; Gepstein *et al.*, 1991; Panjabi *et al.*, 1991a; Panjabi *et al.*, 1991b; Panjabi *et al.*, 1992; Hou *et al.*, 1993; Shapiro, 1993; Shapiro, 1995; Tominaga *et al.*, 1995; Vaccaro *et al.*, 1995; Xu *et al.*, 1995; Karaikovic *et al.*, 1997; Kandziora *et al.*, 2001; Cinotti *et al.*, 2002).

The normal human spine consists, besides the sacrum and the coccyx, of 24 vertebrae: seven cervical (abbreviated: C1 - C7), twelve thoracic (Th1 - Th12) and five lumbar ones (L1 - L5). The vertebrae enclose the spinal cord, which usually ends between L1 and L2 (McCotter, 1916).

Whereas the major function of the vertebral bodies is to carry the body weight and serve as an axis for body mechanics, with the intervertebral discs acting as buffers, the main purpose of the vertebral arch, the pedicles and the laminae, is to protect the spinal cord and to link with the transverse and spinous processes, which serve as the attachment points of various supportive back muscles. The spinous processes also limit, together with the ligamenta flava, extension movements at least of the human thoracic spine (White and Hirsch, 1971).

The spinal cord consists of the grey matter, the nerve cell bodies, and the white matter, containing the nerve fibres. Nerve roots exit from the spinal cord on each vertebral level and provide sensory and motor innervation to the periphery. The white matter includes the dorsal columns, linked with sensory abilities, and the latero-ventral columns, which represent the motor innervation.

The neural canal contains the spinal cord and its nerve roots, the cerebrospinal fluid, the dural sac, extradural fat, ligaments and, just behind the vertebral bodies, a venous plexus. Furthermore, a menigeal recurrent nerve providing nociception to the ligaments, the spine, the dura and the vertebrae can be found in this area. The dural sac extends further caudally and ends mostly on sacral (S) level 1 or 2 (Salamon *et al.*, 1966).

The particular spinal neural situation was reviewed earlier (Rydevik *et al.*, 1984; Group and Stanton-Hicks, 1991) as well as the spinal ontogeny and adult anatomy (Donaldson and Davis, 1903) and its aging related adaptation (Bailey, 1953). Larsen

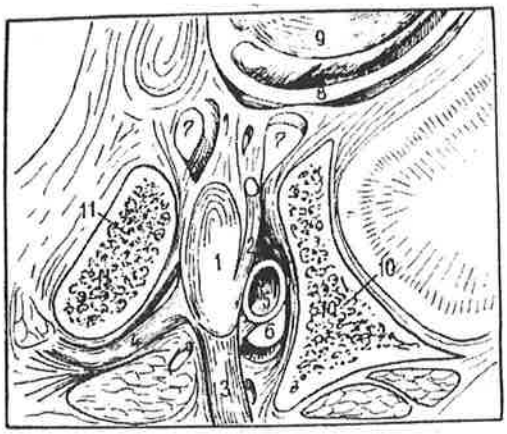
(1985) already discussed widely the specific anatomical interaction of the lumbar spinal nerves and the posterior surface of the vertebrae. He even mentions the fact that the postero-lateral vertebral body parts develop from the same ossification centre, as do the spinal neural arches.

The spinal cord is surrounded among others by its meninges and peridural fat. Between the spinal cord and the osseous and ligamentous borders of the spinal canal, a free space, so called "spinal canal reserve capacity" (Weisz and Lee, 1983), is located, which allows the spinal cord to move freely and independently from body movements.

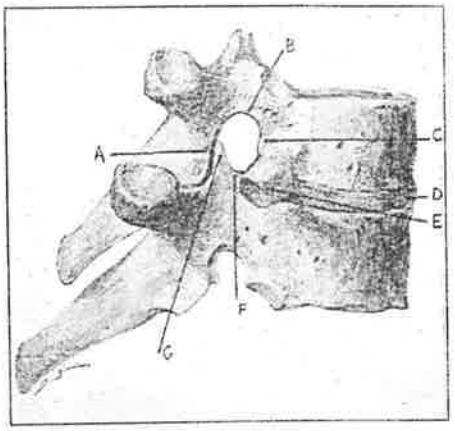
The anatomy of the intervertebral foramen in relation to its surrounding osseous and soft tissue structures has already been widely addressed (Swanberg, 1915; Larmon, 1944; Magnuson, 1944; Epstein *et al.*, 1964; Veleanu, 1975; Crock, 1981; Kirkaldy-Willis *et al.*, 1982; Hasue *et al.*, 1983; Vital *et al.*, 1983; Bose and Balasubramaniam, 1984; Kikuchi *et al.*, 1984; Vanderlinden, 1984; Rauschning, 1987; Hoyland *et al.*, 1989; Mayoux-Benhamou *et al.*, 1989; Stephens *et al.*, 1991; Hasegawa *et al.*, 1995; Ebraheim *et al.*, 1996). Rauschning (1987) describes the outline of the lumbar root canal as being of an inverted teardrop form with an oval shaped intervertebral foramen at its caudal end. Hasue *et al.* (1983) characterize the normal form of the lumbar intervertebral foramen as being oval or almost triangular at least in the cadaveric spine. Bose and Balasubramaniam (1984) call the intervertebral foramen the "external ring" of the nerve root canal with oval size for the two lowest lumbar levels and more circular shape for S1. Lee *et al.* (1988) divide the lateral section of the lumbar spinal canal into three major parts: The entrance zone containing the nerve root and the dura mater; the mid-zone which consists of the dorsal root ganglion, which is usually located in the supero-lateral area and often plays a significant role in lower back pain symptoms (Vanderlinden, 1984; Weinstein, 1986;

Hasue *et al.*, 1989), and the ventral motor nerve root surrounded by fibrous extensions of the dura mater and, finally, the exit zone with the peripheral nerve and its perineurium cover. Vital *et al.* (1983) divide the lumbar radicular canal also into three morphologically different sections, which are the retrodiscal space, the parapedicular space or lateral recess and, the intervertebral foramen. The major factors affecting the intervertebral foramen size are e.g., degenerative changes of the bony borders, increased spinal mobility, disc degeneration, subluxation of the facet joints or bulging of the ligamentum flavum. The intervertebral foramen, the exit zone according to the categorization by Lee *et al.* (1988), contains beside the spinal nerve, which is mostly located in its inferior section, only fat and blood vessels in the upper section of the foramen (Swanberg, 1915).

Surprisingly, most of the intervertebral foramen seems to be filled out by fat tissue, which acts, due to its semi-liquid consistence in living people, as a natural buffer for any physical stress operating on this anatomical region and, in particular, the exiting nerve roots (Swanberg, 1915). According to Swanberg (1915), who examined the microscopic structure of the intervertebral foramen, the neural tissues in the intervertebral foramen also show a lack of major lymphatic vessels. Hoyland *et al.* (1989) investigated the normal and clinically abnormal microscopic structure of the intervertebral foramen and describe its main content similar to previous reports. In a normal intervertebral foramen, the fibrous tissue occupies less than 28%, the neural tissue less than 35% and a lot of vessels of diverse sizes were found (Hoyland *et al.*, 1989). The foramen, according to them, forms an outline of an upside-down pear. Some of the earlier described outlines of the intervertebral foramen could be found in Figure 1.



A



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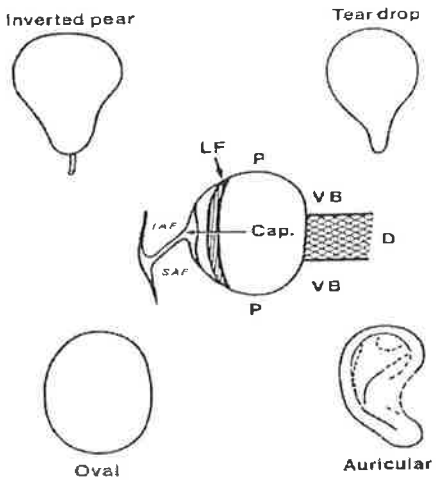


C

Figure 1: Anatomy of the intervertebral foramen (figures unchanged or slightly modified from original references)

A) Intervertebral foramen of the cervical spine (Veleanu, 1975); 1: spinal ganglion, 2: anterior root of the spinal nerve, 3: anterior ramus of the spinal nerve, 4: posterior ramus of the spinal nerve, 5: vertebral artery, 6: vertebral periarterial venous sinus, 7: cervical epidural venous sinus, 8: dura mater, 9: spinal cord, 10: unciform process, 11: upper articular process

B) Bony and cartilage outline of the intervertebral foramen (Swanberg, 1915); A: inferior articular process, B: root of superior vertebral arch, C: vertebral body, D: intervertebral fibro-cartilage, E: head of rib, F: root of inferior vertebral arch, G: superior articular process

C) Intervertebral foramen shape (Stephens *et al.*, 1991); P: pedicle of the vertebral arch, VB: vertebral bodies above and below, D: intervertebral disc, LF: ligamentum flavum, CAP: capsule of zygoapophysial joint, IAF / SAF: inferior and superior articular facets

A precise knowledge of the anatomical peculiarities of the human vertebral column is crucial to understand not only its special purpose and to help to evaluate its specific evolutionary background, but also to understand some particular clinical problems.

The clinical significance of the particular anatomy of the lower human spinal column has already been discussed in detail by Magnuson (1944). Crock (1981) described the anatomy and its linked pathology of the lumbar spinal nerve root canal, which was also reviewed by Rydevik *et al.* (1984). Crock (1981) emphasizes the importance of the "spinal nerve root canal concept" especially for the lowest lumbar region, rather than the use of the term "lateral recess" which, according to him, is just true and useful for a minor part of the spinal nerve pathway. Furthermore, Bose and Balasubramaniam (1984) discuss the particular anatomy of the lumbar nerve roots canals. They introduce the term "external ring" for the exit at the intervertebral foramen. They also provide, besides detailed anatomical descriptions, measurements of the nerve root canal lengths. Veleanu (1972; 1975) addressed the particular anatomy of the cervical nerve root grove and the unco-transversal region. For the cervical nerve groove, he differentiates two parts, the initial radicular part and the terminal groove of the anterior spinal nerve ramus.

The particular situation of the lumbo-sacral dural sac and the linked nerve roots has been discussed widely by Salamon *et al.* (1966) and the anatomy of the lumbar nerve root canals has been highlighted by Bose and Balasubramaniam (1984). Nerve roots in the spinal column have no perineurium, weakening them in strength in comparison to other peripheral nerves (Sunderland and Bradley, 1961) and implying a higher susceptibility to compression. Nevertheless, Hasue *et al.* (1983) and Kikuchi *et al.* (1984) mention an epiradicular membranous layer around the exiting nerve root and Hoyland *et*

al. (1989) describe the dura mater covering the nerve roots at the entry of the intervertebral foramen. Nerve roots fill out approximately 20-50% of the intervertebral foramen dimension and lie anterior to the dorsal root ganglion, which is also a part of the lateral intervertebral foramen and consists of the cell bodies of the sensory neurons (Swanberg, 1915; Bornstein and Peterson, 1966; Panjabi *et al.*, 1983; Vital *et al.*, 1983; Bose and Balasubramaniam, 1984; Vanderlinden, 1984; Hoyland *et al.*, 1989; Hasegawa *et al.*, 1995). Magnuson (1944) states that the nerve ganglion is just slightly smaller than the intervertebral foramen, both apparently measuring 7 mm in average at L4 and L5. The exiting spinal nerve roots pass just below the pedicle of the upper vertebral level, in the upper part of the intervertebral foramen (Kirkaldy-Willis *et al.*, 1982; Rauschning, 1987). Larsen (1985) highlights the fact that the lumbar nerve roots are even more flexible than the more cranial ones due to their longer intraspinal segments, which may have an impact on the infero-lateral posterior vertebral surface.

All these facts have clinical relevance, as discussed later. This is particularly true for example for the interaction between the osseous- and non-osseous parts of the intervertebral foramen and its corresponding nerve roots, which according to Mayoux-Benhamou *et al.* (1989) are key factors in such clinical situations.

Another osteometric landmark of the neural spinal canal is the foramen magnum, located at the skull base. Schaefer (1999) found e.g., that the distance of the foramen magnum from the bi-carotid chord could be used to differentiate human from non-human e.g., chimpanzee, crania. Nakashima (1986) compared types of size of the foramen magnum in male middle Kyushuites with that of male Germans and postulates a possible change of type during individual growth. Nakashima (1986) found a variance in length but not in breadth of the foramen magnum among these groups. Martin (1928) stated that

there is a high individual variability in foramen magnum dimensions. The main diameters of the foramen magnum have already proven their possible predictor qualities for body mass, not only in humans but also in other hominids (Aiello and Wood, 1994). Furthermore, foramen magnum size does not correlate well with spinal cord size in primates but with body weight (MacLarnon, 1996a).

The osteometry of the major spinal regions has been widely covered in the studies by Panjabi *et al.* (1991a; 1991b; 1992). Based on their morphometric research they declare the following major spinal zones to be of transitional nature: C2 - C3, C6 / C7-Th1, Th1 - Th4, Th10 - Th12, L1 - L3, L3 - L5. Furthermore, Putz (1981) investigated and reviewed the major aspect of the spinal anatomy, its ontogenetic development and the functional anatomy with special focus on the spinal joints.

The ontogeny of the human spine has already been addressed by Aeby (1879). He found e.g., that adults have a relatively longer lumbar spine but shorter cervical spine, with the thoracic spine being relatively similar to its size in childhood. According to Aeby (1879), the spinal canal dimensions change remarkably by becoming relatively smaller in adulthood. Additionally, the adult spine is slimmer in the transverse plane (Aeby, 1879). Also Donaldson and Davis (1903) as well as Lassek and Rasmussen (1938) reported the ontogenetic aspects and the adult anatomy of the spinal cord. According to Donaldson and Davis (1903), the majority of the spinal cord area increase occurs after the age of five years, with a relative higher increase of the white matter and more prominent change in the thoracic region. Lassek and Rasmussen (1938) describe a relatively bigger increase of the white matter and of the thoracic spinal cord as well as a relative shrinking of the spinal cord length from the newborn to to adulthood; with the average spinal canal length being 410 mm. Donaldson and Davis (1903) found an average length of the spinal

cord in adults of 441 mm, with an indication for a correlation between the length of the vertebral column and the osseous spine.

Furthermore, Donaldson and Davis (1903) found differences in adults between spinal cord cross-section areas and volumes of the grey and white matter at various spinal levels. Whereas the maximum spinal cord area locates in a mixed sex sample at level C6, followed by the values on level L3 and L5, the ratio between white and grey matter varies depending on vertebral level, with the grey matter usually being approximately 20% of the white one (Donaldson and Davis; 1903). Lassek and Rasmussen (1938) found an average ratio of approximately 18%. The highest volume of grey matter is found, according to Donaldson and Davis (1903), at the level C6, whereas the highest value of grey matter area can be found at level L5. Donaldson and Davis (1903) further explored the relation between grey matter and spinal nerves at various vertebral levels. They found that only for the cervical and sacral region there is a correspondence between the two, whereas for the thoracic and lumbar section there is not. In the latter two, the grey matter volume is bigger than expected, explained by them as a reaction of vertebral elongation during growth rather than increased neural complexity at these levels. McCotter (1916) reports an average spinal cord length for White males of 448 mm and for White females of 418 mm, as well as 434 mm in Black cadavers with unlisted sex. Furthermore, Ravenel (1877) reports lengths of the total vertebral column for fresh male and female cadavers. He highlights the high degree of inter-individual variability of spinal osteometric measurements, which reaches in some dimensions up to a third of the mean value.

Surprisingly, the juvenile spine reaches at a very early age most of its adult dimensions (Porter and Pavitt, 1987). However, the juvenile spinal canal still further changes its shape by maturing (Porter and Pavitt, 1987). Wolf *et al.* (1956) state that the

lower clinically critical limits of the sagittal spinal canal dimensions are attained at the age of four to five years, whereas the adult size, according to them, may be reached at an average age of 12 years. Clark *et al.* (1985) state that approximately 90% of the adult vertebral canal size is completed by late infancy, which makes the spine more vulnerable to prenatal growth disruptions than other parts of the human body.

Various reports already addressed the relationship between spinal cord size and brain size (Marshall, 1892; Latimer, 1950; MacLarnon, 1996b). Latimer (1950) reports for Guinea pigs correlations between spinal cord weight and total brain weight as well as the weight of various brain parts, between spinal cord weight and length and between spinal cord weight and both body weight and length. Latimer (1950) found weaker correlations for the spinal cord length than weight e.g., in relation to body weight. MacLarnon (1996b) describes also a correlation between brain weight and spinal cord weight for primates. Marshall (1892) calculated the spinal cord to be 2.1 % of the brain weight in humans. MacLarnon (1996b) lists, based on own studies and summarized from earlier published data, an average brain weight of an adult 60 kg human to be 1274 g and a spinal cord weight of 29.7 g. These values are from unpublished data sources by Martin and MacLarnon and differ from established averages of approximately 59 kg and brain weight of about 1350 g (Pakkenberg and Voigt, 1964; Beals *et al.*, 1984; Henneberg, 1990), and, therefore, some caution is necessary for these data. The overall spinal cord length was reported in this study to be 448 mm in males and 413 mm in females (MacLarnon, 1996b). Nevertheless, Elliot (1945) found no evidence for a correlation between individual stature, and weight, as well as sex or age and spinal cord dimensions in humans.

The size of the vertebrae and its use for estimation of body size is still doubtful (Martin and Saller, 1957; Tibbetts, 1981). Tibbetts (1981) found that the coefficient of correlation mostly increases the larger the vertebral numbers included in individual stature estimation are. Gozdziewski *et al.* (1976) found a clear correlation between thoraco-lumbar spine length and individual height in a sample of living individuals. Karaikovic *et al.* (1997) describe a dependence of pedicle diameters on individual body height of 30% up to 70%. In a modern Polish medical student sample individual height was significantly correlated with the length of the thoraco-lumbar spine (Gozdziewski *et al.*, 1976). Also, Minne *et al.* (1988) mention a clear correlation between individual stature and vertebral dimensions. In a radiographic study on living women, Gallagher *et al.* (1988) found a correlation between thoraco-lumbar vertebral anterior and posterior height and individual height or weight. Amonoo (1985) found a change in the mid-sagittal neural canal diameters in relation to alterations of the sagittal diameter of the vertebral body. For both sexes, he mentions for such a ratio a value of 0.5 on L2 - L5 and 0.6 on L1 respectively.

On the other hand, in the osteometric study published by Berry *et al.* (1987), the combined vertebral body heights did not show a correlation with the recorded individual height of the deceased person. Piera *et al.* (1988) found no correlation between pedicle transverse diameter and its equivalent dimension of the neural canal. Katz *et al.* (1975) found no influence of stature on human cervical vertebra morphometry. Contrary, the "ponderal index", which is body height divided by $\sqrt[3]{}$ body weight, as well as the head weight correlated at least with some of the cervical spine measurements.

The influence of body size and weight on spinal morphometry, especially the size of the neural canal diameters has already been addressed (Legg and Gibbs, 1984; Porter *et*

al., 1987; Sanders, 1991; MacLarnon, 1995; Harrington *et al.*, 2001). Porter *et al.* (1987) found that patients with a narrow sagittal spinal canal diameter were 22% heavier than their counterparts with a wide one. Body weight is proposed to be the best variable reflecting body size (Jungers, 1984). Harrington (2001) did not find a correlation between individual stature, weight and body mass index for the occurrence of a disc herniation in the lower lumbar region. On the other hand, Heliövaara (1987) describes a link between stature and in particular moderate increase in body mass index and, only in males, the hospitalisations due to herniated lumbar discs. Legg and Gibbs (1984) found no clear correlation between individual stature or body weight and lumbar spinal canal dimensions. Furthermore, Murrie *et al.* (2003) found a more prominent lumbar lordosis in individuals with a higher body mass. Furthermore, body weight seems not to be related with the dorsal root / ventral root ratio in the spinal canal (Corbin and Gardner, 1937). Nevertheless, body weight in mammals is correlated with the size and number of spinal nerve root fibres (Dunn, 1912).

In an archaeological sample, Hibbert *et al.* (1981b) describes a correlation for individual long bone sizes and transverse spinal canal diameter, but not for its sagittal counterpart. Additionally, Porter and Pavitt (1987) were unsure about the direct influence of small transverse juvenile spinal canal diameters, the known stress marker dental hypoplasia and individual stature. Jankauskas (1994) reports a correlation of less than 0.4 between individual stature and longitudinal spinal measurements. Furthermore for a female sample, Ross *et al.* (1991) could not detect a significant change in vertebral morphology such as anterior / posterior vertebral body height ratio with individual stature. McCotter (1916) did just find a tendency but no clear correlation between spinal cord length and individual stature as measured by height or vertebral column length. In a

clinical study by Harrington *et al.* (2001), individual height, weight or body mass index did not have an influence on the occurrence of disc herniation. Nevertheless, there was a correlation between vertebral body diameters and individual body weight, but a just very weak one with pelvic breadth.

Sexual dimorphism and age-related adaptations of the human spine

It is well known that sex influences the spinal morphology, since e.g., already Dwight (1894) reported longer relative lumbar regions in women. Martin (1928) mentions, that the female ventral vertebral body height is usually smaller than its male counterpart, with an especially prominent difference for the cervical and upper thoracic region. MacGibbon and Farfan (1979) found no influence of sex on the occurrence of transitional lumbar vertebra and rudimentary ribs. However, they found the transverse process at L5, in relation to the reference one at L3, to be longer in females. This would predispose females to have more likely degenerative changes at L4 / L5 and males at L5 / S1 (MacGibbon and Farfan, 1979). The overall morphology of the lumbar spinal canal does not show any sex dependent variation (Piera *et al.*, 1988). Amonoo-Kuofi (1985) describes in a study of vertebral columns from Nigeria a narrower and generally more variant sagittal diameter of the neural canal for females. Francis (1955) reports to have found only absolute smaller values for female spines, but without any apparent relative alterations of the vertebral dimensions in relation to male samples. Furthermore, Mitra *et al.* (2002) found only non-significant differences in pedicle size in relation to sex, mostly similar to the results presented by Ebraheim *et al.* (1997), Hou *et al.* (1993) or Xu *et al.* (1995). In addition, Karaikovic *et al.* (1997) did not find sex-dependent differences in pedicle dimensions, once the influence of different body height was taken out of the

calculations. Nevertheless, for the pedicle height, Olsewski *et al.* (1990) found a significant sex difference, with women having smaller dimensions than males, for most lumbar levels. Burrows (1963) could not find a significant difference in sagittal spinal canal diameter between sexes, he describes a difference of usually 1 mm or less. No significant differences have been shown in foraminal dimensions in relation to sex (Ebraheim *et al.*, 1996). Also Hinck *et al.* (1966), in their study of the interpediculate distance as observed on roentgenograms, stress the only minor influence of sex on at least a selection of spinal dimensions. In a biomechanical study, Nachemson *et al.* (1979) found no correlation between age or degenerative lower back pathologies and altered mechanical behaviour of the lumbar motion segments. Furthermore, they only describe a slightly higher flexibility of female motion segments to bending or compression forces. Sex differences were also found by Tatarek (2001) with larger neural lumbar canals in males than in females. This is in general consistent with the findings reported by Lee *et al.* (1995) for the mid-sagittal diameter but not for the interpedicular diameter. Piera *et al.* (1988) found in an X-ray based study, that there is a link between sex and interpeduncular distance of lumbar L1 - L4. Katz *et al.* (1975) found in another X-ray based study on recent volunteers, that males have significantly larger cervical vertebrae height and sagittal width than females. These findings by Katz *et al.* (1975) may be caused by the fact that for the two sexes individuals of the same percentile and not absolute stature were chosen and, therefore, males were bigger on average. Van Schaik *et al.* (1985) found smaller osteometric length values in females, but no differences in vertebral angles or ratios. Horwitz (1939) also reported, at least for all measurements but not for the indices, a highly significant sexual dimorphism with a general tendency of kyphosis in males in thoracic spine. Minne *et al.* (1988) describe only a non-significant sexual difference in

spinal morphology; such as the higher lumbar increase in vertebral body height in females. Females also show a significantly more prominent lumbar lordosis (Murrie *et al.*, 2003). In an osteometric study on the lumbar spinal canal significant sexual dimorphism was found for the ratios of the spinal canal dimension to vertebral body (Kikuchi *et al.*, 1977). Men have significantly larger lower lumbar vertebral endplates but the shape ratio of them seems not to differ between sexes (Harrington *et al.*, 2001). In a sample of asymptomatic Polish medical students Gozdziewski *et al.* (1976) found a larger thoraco-lumbar spine in the male sample than in the females. Berry *et al.* (1987) did not separate sexes in their study on spinal morphometry. According to them, even without separating the data, sex showed a coefficient of variation of mostly less than 10 %. In the thoracic spine, Piontek (1973) detected that females show a stronger increase caudally in main vertebral body dimensions, such as sagittal and transverse diameter. The single exception was vertebral body height (Piontek, 1973). Piontek (1973) describes also in the thoracic spine a higher enlargement of the sagittal dimension caudally than for the transverse ones, whereas for the lumbar spine this trend seems to be opposite. In the Early Medieval samples presented by Piontek (1973) the relative increase of vertebral body height was higher for males than females and the relative increase of the sagittal dimension was bigger for females than males.

The earlier reports on the influence of aging on spinal morphometry are equivocal. Age-related alterations of the spinal morphometry (Jacobi, 1927; Hurxthal, 1968; Trotter and Hixon, 1974; Ericksen, 1976; Hansson and Roos, 1980; Porter *et al.*, 1980; Weisz and Lee, 1983; Gallagher *et al.*, 1988; Piera *et al.*, 1988; Jankauskas, 1992; Hermann *et al.*, 1993; Edmondston *et al.*, 1994; Jankauskas, 1994; Diacinti *et al.*, 1995; Jason and Taylor, 1995; Lee *et al.*, 1995; Humphreys *et al.*, 1998; Tatarek, 2001), changes in

relative spinal region length (Schultz, 1961; Jason and Taylor, 1995) and vertebral bone mineral content (Hansson and Roos, 1980) have been reported so far. Furthermore, aging results in a general decrease of skeletal weight, with the male bones being significantly heavier than the female ones (Trotter and Hixon, 1974). In a radiographic study on asymptomatic females, Gallagher *et al.* (1988) found no correlation of the anterior vertebral body height and individual age, whereas the posterior height was negatively correlated. Surprisingly, in a similar study conducted by Davies *et al.* (1989), no change in either anterior or posterior vertebral body height was reported for asymptomatic females as well as women suffering from osteoporosis within time periods of at least 10 years span shortly before menopause. Contrary, Black *et al.* (1991) conclude that no morphometric changes occur depending on age, while Hermann *et al.* (1993) found just a very weak interference. Hermann *et al.* (1993) even argue that the described aging effect could be due to secular increases in individual stature within the cohort. However, no age related changes in lumbar spinal canal dimensions were found in an osteometric study by Kikuchi *et al.* (1977). Also the lumbar lordosis seems not to change with age (Murrie *et al.*, 2003). Edmonston *et al.* (1994), in cadaver spines of elders, found just a weak correlation of vertebral body height ratios and bone density. Bone density is representative of bone remodelling, which in the elder spine can be present in form of wedging and increased thoracic kyphosis. Piera *et al.* (1988) describe the absence of any relation between general lumbar spinal morphology and age. Nevertheless, the lumbar interpeduncular distance in particular seems to increase with age, more prominent on the upper than on the lower lumbar spine (Piera *et al.*, 1988). In the same study, a correlation of L1 - L4 interpeduncular distance in relation to sex was found as well. By focusing on the anatomy of the human spinal cord, Elliot (1945) found not only a high degree of inter-

individual variation, but also independence of individual sex, age or weight from the cord dimensions. In addition, Bailey (1953) did not find any major atrophy of the spinal canal in the elderly. However, in a study on albino rats, Dunn (1912) reports a clear decrease of nerve tissue with older age in the cervical nerve root.

The particular aspect of spinal ontogeny was highlighted, as discussed above, by Donaldson and Davis (1903). In addition, Aeby (1879) emphasizes the ontogenetic impact on relative dimensions in the vertebral column. Jacobi (1927) describes in his cadaver series an increase in vertebral body heights within the young adult age group, most likely due to still ongoing vertebral growth. Furthermore, he found for most anterior and posterior vertebral body heights a decrease for the oldest group, aged 70 and above. Similar age related changes were addressed by Hurxthal (1968) with in particular an anterior decrease in vertebral body height in the elderly and a widely seen slight wedging of the dorsal part of the vertebrae. For the spinal cord of the elderly, Bailey (1953) did not find a decrease in size nor frequent thickening of the meninges, but occasionally calcareous deposits and quite often mild arteriosclerosis. Burrows (1963) could not find a change in cervical sagittal spinal canal dimensions with age. The influence of aging and menopausal status was examined by Diacinti *et al.* (1995). According to them, in the female spine there is a decrease in vertebral body height of approximately 1.5 mm per year with a more prominent trend for the anterior part of the vertebra.

Biomechanics and spinal morphology

The unique stability and instability of the human spine was discussed among others by Louis (1985). His proposed classic "three-column" theory of spinal stability is in accordance with the normal ossification pattern of the spine. The first pillar is the

vertebral body, whereas the second and third ones are formed by the posterior articular processes, all of them resisting the forces of gravity (Louis, 1985). Louis (1985) found an increased size of the three pillars and of the flexor and extensor trunk muscles caudally. According to his model, the vertical axial stability is maintained by the three pillars, which are toughened by the horizontal vertebral arch. Louis (1985) attributes the spinous processes no role in maintaining spinal stability. Transverse stability of the spine is reinforced by bony and ligamentous stabilizers, varying for flexion, extension or rotation movements (Louis, 1985). Louis (1985) describes the spinal segment units as consisting of three joints, the intervertebral disc and the two zygoapophysial joints; the latter ones orientated at a different angel to the disc and supporting the weight bearing. Depending on the body position and physical load, either the disc of the two posterior joints resists compression forces with the other one resisting shearing impact (Louis, 1985).

The important role of the so called posterior elements, consisting mainly of the facet joints, parts of the laminae, the spinous processes and some ligaments, was examined by White and Hirsch (1971) by showing the biomechanical result after the ablation of these structures. Putz (1981) not only describes the main osseous aspects of the human spine but focuses especially in his study on the anatomical and functional particularities of the vertebral joints as they act in collaboration with other bony structures, ligaments and muscles. He divides the human spine in various *"Bewegungsregionen"*, motion regions, which show a different active and reactive pattern at the various positions and forces acting on them. These segments stretch, according to him, from C1 to C3, C3 to Th1(2), Th1(2) to Th(11)12, and Th(11)12 to the end of the sacrum, with the thoracic part consisting of two major regions, Th1 to Th8 and Th8 to Th12. Putz (1981) widely discusses the functional implications of the particular

anatomy of the vertebral joints. He describes the axial pressures to be transmitted to the spine in three main axes, the vertebral body and the two vertebral joints. The importance of the zygoapophysial joints in maintaining spinal stability was also highlighted by Putz (1981). Veleanu (1972; 1975) highlights the importance of the "unco-transverso-articular-complex" in particular for the mechanical stability of the cervical spine, with the transverse epiphysis as a blocking factor preventing mechanical instability and protection for the neural and vascular contents of the neural pathways. Schmorl and Junghans (1968) used the term "motor segment" to describe all the soft tissue linking the disc and the apophyseal joint complex.

The impact of axial loading on the human spine with a particular focus on the posterior vertebral body and the intervertebral disc was studied by Larsen (1985). The concavity of the posterior vertebral body surface is explained in his model as caused by load induced traction forces as well as the pressure acting by the cerebrospinal fluid. Adams *et al.* (1994) and Panjabi *et al.* (1976) already discussed the impact of axial loading on motion segments, which consists of two adjoin vertebra and their intervertebral discs. The lack of this axial impact on the spine in cadaveric studies is discussed as a weak methodological point e.g., by Fujiwara *et al.* (2001). Both, flexion and extension biomechanically influence in different ways the various spinal components.

The amount of physiological forces acting on the healthy vertebral column, even in simple movements only, is quite astonishing. Nachemson (1966) detected, in an experimental *in vivo* study in sitting positions, involved forces of at least twice the individual body weight above the selected mid-lumbar vertebral levels; such forces are ranging from approximately 1000 N up to 1800 N. The decrease of these forces to roughly half of their value in upright standing situation was explained by Nachemson

(1966) as a result of smaller forces impacting from the muscles such as psoas major in this particular position. An even higher decrease was found in a physiological reclining movement. The load increases dramatically if one bends forward, especially with weight bearing hands. For such a situation forces of up to four times of the individual's body weight working on the lumbar intervertebral discs have been proven by Nachemson (1966). Apparently, the ligamentous components of the spine are not strong load bearing forces, but work together with the rib cage as stabilizer of the spine (Nachemson, 1966). Nachemson (1966) emphasizes the extremely high shearing forces, which act on the dorsal part of the anulus fibrosus and may be of clinical significance as well. In another biomechanical study, Nachemson *et al.* (1979) found no clear influence of age or sex on physical performance of lumbar motion segments. Only females seem to have segments that are slightly more flexible in response to bending and compression forces. Furthermore, Veleanu (1972; 1975) highlights in his study of macerated and cadaveric cervical spines, the importance of the transverse process within the "unco-transversoarticular" complex in limiting possibly pathologic movements. Adams *et al.* (1994) examined the influence of flexion and extension on the various load-bearing spinal structures. Surprisingly, Adams *et al.* (1994) conclude that a mild flexion is the best compromise for a spinal position in weight bearing.

Osteometric findings of earlier spinal studies

Spinal morphometry differs essentially for each vertebral level (Black *et al.*, 1991; Hermann *et al.*, 1993) and is reported remarkably different in various studies.

The ventral vertebral body height, according to Lanier (1939), increases from C3 caudally, with the exception of C5 and C6 that have the smallest values. Hermann *et al.*

(1993) report a consistent increase for both sexes from Th4 caudally. Anderson (1883) describes a decrease caudally in anterior vertebral body height for most of the cervical spine with an increase of its size caudally towards L3, with the second last lumbar level being smaller but the last lumbar level being of absolute highest value. Edmondston *et al.* (1994) describe for the thoraco-lumbar spine in the elderly, a caudal increase in ventral vertebral body height, except for the mostly constant mid-thoracic region. Ross *et al.* (1991) found an increase in anterior vertebral body height, measured in an X-ray study on postmenopausal women, from thoracic levels caudally to L3, with a subsequent slight decrease for the two last lumbar levels. Jankauskas (1994) in his osteometric study of an archaeologic sample found a decrease in anterior vertebral body height for level C3 to C6 with an increase in size caudally to L5, mostly similar for females and males. Minne *et al.* (1988) list for males a steady increase in anterior vertebral body height caudally, whereas females reach the highest value in anterior vertebral body height at level L3. In another radiological study, Hurxthal (1968) found in females an increase in anterior body height caudally of Th7. Other radiographic studies (Nissan and Gilad, 1984; Gilad and Nissan, 1986) report a decrease followed by an increase for the anterior height of the cervical vertebrae and similar for the lumbar levels but with an increase from level L4 to L5. Berry *et al.* (1987) report a consistent increase caudally in anterior vertebral body height in the thoracic and lumbar spine. Gallagher *et al.* (1988) describe an increase in anterior vertebral body height in a sample of living asymptomatic females from Th3 caudally to L3 with a slight decrease for L4 and another increase at the last lumbar level. Similarly, Davies *et al.* (1989) found in their radiographic study on healthy women that the anterior vertebral body height increases caudally from Th7 to L4. The anterior vertebral body height increases caudally in the female cadaver sample, as examined by Aeby (1879),

with the exception of the lower cervical spine and Th6. Cyriax (1920) describes for a sample of macerated spines of both sexes a consistent increase in anterior vertebral body height caudally. The thoracic and upper lumbar anterior vertebral body height, according to the study on cadaver spines by Jacobi (1927), continuously increases caudally. Tominaga *et al.* (1995) found mostly an increase in anterior cervical vertebral body height caudally. In the osteometric study by Marchesi *et al.* (1988) mainly an increase caudally in anterior vertebral body height was reported for the mid-thoracic to lumbar spine.

Posterior vertebral body height is strongly correlated with anterior body height with a correlation coefficient of 0.74 (Clark *et al.*, 1985). The posterior vertebral body height shows a steady caudal increase for the whole thoracic spine, with a maximum at L1 and a decrease in size for the rest of the lumbar region (Lanier, 1939; Hermann *et al.*, 1993; Edmondston *et al.*, 1994). Anderson (1883) describes mostly an increase of posterior vertebral body height caudally for the thoracic spine and a further increase for the upper lumbar spine, but a decrease in size for the last three lumbar levels. According to Minne *et al.* (1988) the posterior vertebral body height increases, as measured in their study caudally from Th4, in the thoracic spine and reaches in both sexes its highest value at L3. Hurxthal (1968) found in females an increase in posterior vertebral body height from Th7 to L3 with a slight decrease for the last two lumbar levels. Putz (1981) describes a decrease from C3 to C7 with a continuous increase in size for the posterior vertebral body height caudally, with a maximum on L1 and a caudally decline within the lumbar spine. In an X-ray based study on healthy elderly women, Ross *et al.* (1991) found increasing values in posterior vertebral body height from the thoracic spine down to L2 with a slight decline more caudally. Also Berry *et al.* (1987) found an increase in

posterior vertebral body height from upper thoracic level up to L2 with a decrease caudally. Jankauskas (1994) reports, for his historic samples, a decrease in posterior vertebral body height caudally from C3 till C7, with a subsequent increase in size to L1. According to him, the lumbar spine shows caudally a decrease in posterior vertebral body height for males but mixed patterns for females. In a study on asymptomatic females, Gallagher *et al.* (1988) found an increase in posterior vertebral body height from Th3 to L3, with a decrease in size for the last two lumbar levels. The same findings were mentioned by Davies *et al.* (1989), who showed an increase in posterior vertebral body height for their sample of radiologically assessed measurements of female spines caudally of Th7. In the female sample of Aeby (1879) the posterior vertebral body height increases caudally, with the exception of the lower cervical spine. The posterior vertebral body height, as measured by Jacobi (1927) on thoracic and upper lumbar levels, increases caudally with the exception of the mid-thoracic region. Panjabi *et al.* (1991a; 1991b; 1992) found a decrease of the posterior vertebral body height in the upper cervical spine, with a steady increase from the lower cervical spine caudally to level L2. For the cervical spine, Tominaga *et al.* (1995) found an increase caudally in posterior vertebral body height. Marchesi *et al.* (1988) report an increase in posterior vertebral body height caudally from the mid-thoracic spine to L3 with a decrease at L4 and L5. Gilad and Nissan (1984; 1986) found a caudal decrease followed by an increase in the posterior cervical vertebrae height, but on the lumbar level an opposite trend with the highest value for L2.

The particular anatomy of the posterior vertebral surface has been addressed by Larsen (1985). The foraminae of the basivertebral veins as well as the concave shape of the dorsal part of the lumbar vertebra are highlighted by him. The maximum medial

concave depth was in his sample approximately 0.5 mm for both levels, L1 and L5, respectively. He found no correlation between the posterior vertical lumbar scalloping and posterior vertebral body height or maximum transverse dimension. The scalloping of the lumbar vertebrae is biomechanically explained by Larsen (1985) by various factors, such as axial loading and pressure originating from the cerebrospinal fluid. He explains the development of the lumbar posterior vertebral surface to be a result of its surrounding structure, namely the spinal canal and its contents such as the pressure in the epidural space. The fact that the epidural space changes in its size from cranial to become larger more caudally is another aspect. Furthermore, Larsen (1985) mentions that in cases of narrowing of the spinal cord space the epidural space is altered in form of decreased content of epidural fat, which may result in an decreased buffer action, which then will interfere with the posterior surface of the vertebra. The influence of the dural sac and its contents, according to Larsen (1985), may be more important at the foetal stage, since at this time the direct physical contact of these two anatomical structures is more intense than later in life.

The sagittal diameters of the vertebral body, as measured by Lanier (1939) on the superior and inferior surface level of each vertebra, increase constantly caudally with the single exception of C7 and L5. Others (Nissan and Gilad, 1984; Gilad and Nissan, 1986) report for the cervical spine mostly a caudal increase in size and for the lumbar spine a similar mostly caudal increase for the lower sagittal surface diameter, whereas the upper sagittal diameter increases only through L3 and decreases further caudal. Katz *et al.* (1975) found in an X-ray based study of the cervical spine trends similar as to those described by Lanier (1939), with C5 having the smallest absolute height, whereas C3 showed the minimal sagittal diameter. For all of the cervical vertebrae, Katz *et al.* (1975)

found higher values for the sagittal diameter than for the average vertebral body height. Larsen and Smith (1980b) report in a myelographic study of the lumbar spine an increase of the sagittal vertebral body diameter from L1 to L3 with identical values for the more caudal levels. The results were similar for both sexes (Larsen and Smith, 1980b). Berry *et al.* (1987) report, with the exception of the mid-thoracic level, a mild increase in the main vertebral body diameters from upper thoracic caudally. Anderson (1883) in an osteometric study found mostly an increase of the sagittal diameter of the vertebral body caudally. Scoles *et al.* (1988) report in their study on macerated spines for both sexes in the thoraco-lumbar region a continuous increase in sagittal vertebral body dimension caudally. Postacchini *et al.* (1983) found mostly an increase in sagittal and transverse vertebral body dimension from L1 caudally. Piontek (1973) mentions an increase in vertebral body dimensions at all levels caudally. This increase was in the cervical spine, according to him, more prominent in females. For both females and males the sagittal vertebral body diameter seems to increase caudally, with single exception on a few selected vertebral levels (Aeby, 1879). Surprisingly, sagittal and transverse cord diameters, according to Elliot (1945), correlate only vaguely with each other. He also describes the cervical enlargement of the spinal cord, at level C5 / C6, to be flatter in sagittal direction, the thoracic to be minimal at level Th6 / Th7 and the lumbar enlargement at level L5 / S1 to be of small and round shape.

The vertebral body surface area shows in the lower thoracic spine an increase with a maximum at the second last lumbar level (Shapiro, 1993). This surface area is, again with the exception of the last lumbar level, well correlated with the body weight, but the human data in the study by Shapiro (1993) were merged in a sample with great ape. Davis (1961) examined the relationship between vertebral body area, pedicle dimension and

transverse processes size in the lumbar spine. He concludes that L4 is larger than L5 on average, but it is the other way round for the pedicles. He found no significant correlation between the vertebral body area changes and transverse process size. He explains the caudal transition of the trunk and upper limb weight in the lower lumbar area to be done by lumbo-sacral zygoapophyseal joints but also substantially by ilio-lumbar joints.

The transverse vertebral body diameter, as measured by Lanier (1939) on the inferior surface of the vertebral body, continuously increases caudally, with exceptions of Th3 to Th6 and at L5. Larsen and Smith (1980b) report a steady increase for the lumbar transverse vertebral body dimension caudally. Jankauskas (1994) found for most of the cervical levels in males an increase of the transverse vertebral body diameter caudally, a decrease in the upper thoracic levels and a subsequent increase in size in almost all of the more caudal levels. According to him, females show a similar pattern. Scoles *et al.* (1988) describe for both sexes a steady increase caudally, on the thoraco-lumbar level. Aeby (1879) found in his cadaveric sample for both males and females similar trends in transverse vertebral body diameters. The transverse diameter decreases caudally both in the upper cervical and thoracic spine, shows an increase in size in the lower cervical and thoracic as well as the whole lumbar spine (Aeby, 1879). Anderson (1883) describes for the transverse width of the vertebral body, which was in his osteometric study measured as the maximal width varying in relative position on each vertebral level, mostly an increase in size caudally. The only exception in his study was the upper thoracic spine, which showed a decrease of this measurement caudally from level Th2 to Th5. Cyriax (1920) found for the transverse vertebral body diameter of a sex pooled sample an increase in size in the cervical spine, with a slight decrease in the upper thoracic spine and another increase caudally.

The size of the intervertebral discs, according to radiological studies (Nissan and Gilad, 1984; Gilad and Nissan, 1986), mostly shows an anterior and posterior increase increases in height in the lumbar segment, whereas no such clear trend is visible for the cervical intervertebral disc anterior and posterior height (Kandziora *et al.*, 2001). The cervical intervertebral discs are relatively larger than the lumbar ones (Brain, 1948). Furthermore, Aeby (1879) found that the increase in intervertebral disc size is mainly in the lumbar spine. He provides data on intervertebral disc height for all vertebral levels and both sexes, whereas Tribus and Belanger (2001) only do for the last lumbar one and Kandziora *et al.* (2001) for the cervical spine. Jacobi (1927) presents similar results in his sample of cadaver spines from Th1 to L3, with the major increase of the intervertebral disc to be found in the upper lumbar spine. Also Piontek and Zaborowski (1973) list normative data on the intervertebral disc height, with mostly an increase caudally for the cervical spine. Hurxthal (1968) provides in a radiological study on women data for the lower thoracic and lumbar intervertebral disc heights in normal as well as osteoporotic individuals. Hurxthal (1968) found an increase caudally. Hasegawa *et al.* (1995) describe in their cadaver study of the lumbar spine no increase in intervertebral disc height caudally.

The maximum spread of the transverse processes increases in the cervical spine caudally, decreases through the thoracic spine and reaches its smallest size at Th12. Finally, it increases again through the lumbar spine and shows its overall highest value at L3 and L5, respectively (Lanier, 1939). Francis (1955) found a decrease of the transverse process size from C1 to C3 with an increase for the caudal half of the cervical spine. Cyriax (1920) reports an increase caudally of the total transverse process width within the cervical spine, with a stabilization or clear size decrease within the thoracic spine, and

another strong increase for the lumbar vertebral levels. Panjabi *et al.* (1991a; 1991b; 1992) report a decrease of the transverse process width for the upper cervical spine with an increase caudally. From Th1 caudally, the transverse process width decreases again through Th4, shows caudally a slight increase with a further drop in size at the lowest thoracic levels (Panjabi *et al.*, 1991b). With the exception of L4 this vertebral dimension show an increase in the lumbar spine caudally (Panjabi *et al.*, 1992).

The spinous process, as measured including the sagittal diameter of the spinal canal in an X-ray study (Nissan and Gilad, 1984), decreases from C3 caudally and increases in size at the caudal half of the cervical spine. According to this particular study, this is not the case for the lumbar level, where there is an opposite trend visible with an initial increase caudally and later decrease in size for the lower lumbar spine.

The normal osseous spinal canal diameters follow mostly a different pattern. According to Larsen and Smith (1980b) there is no correlation between the main vertebral body dimensions and the spinal canal outline, but there is a correlation between the bony spinal canal and the dural sac size (Larsen and Smith, 1980a).

The sagittal spinal canal dimension shows generally an increase in the cervical segment with its highest dimension on C6, except for C2 (Panjabi *et al.*, 1991a). In the thoracic spine it shows caudally of Th2 an increase to reach a maximum at Th6, with a subsequent further decrease in the lower thoracic spine (Panjabi *et al.*, 1991b). The two lowest thoracic levels show another increase in size, which continues to L1 (Panjabi *et al.*, 1991b; Panjabi *et al.*, 1992). From L1 caudally the sagittal dimension decreases to L3 and shows another increase in the last two lumber levels (Panjabi *et al.*, 1992). At L5, with the exception of C2, the overall biggest sagittal spinal canal diameter can be found (Panjabi *et al.*, 1991a; Panjabi *et al.*, 1991b; Panjabi *et al.*, 1992).

The sagittal spinal canal diameter shows a mild increase caudally with relatively and absolutely higher measures for the C3 - C5 and Th11 - L2 regions (Lanier, 1939). Wolf *et al.* (1956), based on an X-ray study, describe a decrease in sagittal spinal canal diameters from C1 to C4, with similar values for the lower cervical levels. Burrows (1963) in a similar study, found caudal of C2 a slight decrease in cervical sagittal spinal canal dimensions, with the osseous cervical spinal canal to be shaped like a "triangular tube", with the interpedicular width being much bigger than the sagittal dimension. Furthermore, Burrows (1963) mentions that the spinal cord seems to have more than sufficient space, especially in the transverse dimension. Dommisse (1974; 1975) highlights the fact that the human spinal canal shows the narrowest part in the mid-thoracic region, with in most cases particularly involving Th6. Dommisse (1974; 1975) describes a decrease in sagittal and transverse osseous diameters of the spinal canal from upper thoracic to the narrow zone, with an increase caudally. This most constricted spinal canal region is the region, where the vascular supply of the spinal cord is also to be least rich (Dommisse, 1974). This could result in certain instances in paraplegia (Dommisse, 1974). Whereas the transverse diameter of the cervical spinal canal shows an increase in size caudally, the sagittal dimension shows a decrease from C3 to C4 with a mostly stable size caudally, as shown in a mixed-sex cadaveric sample (Tominaga *et al.*, 1995). In an osteometric study conducted by Francis (1955), the main diameters of the spinal canal show an inconsistent size pattern caudally, depending on the sex and populational background of the sample. In general, Francis (1955) lists for the sagittal diameter in males a decrease in size caudally only for the upper cervical part with the lower caudal half of the cervical spine having roughly similar values; whereas in females the sagittal diameter decreases caudally throughout the whole cervical spine. For the transverse

dimension, Francis (1955) found generally for both sexes a decrease in size in the upper half of the cervical spine and an increase in size for the caudal cervical spine. The minimal sagittal diameter of osseous spinal canal shows, in an osteometric study by Marchesi *et al.* (1988), in the mid- / low thoracic and lumbar spine two major values at L1 and L5, respectively. Aeby (1879) found for both sexes a puzzling pattern of size alterations in sagittal spinal canal size caudally. In general, the canal size decreased caudally in the cervical spine, whereas mostly in the upper thoracic spine this dimension increased and was mostly smaller but stable in size caudally in the lower thoracic spine (Aeby, 1879). The lumbar spine showed for both sexes caudally an increase followed by a decrease (Aeby, 1879), with males having smaller absolute sagittal lumbar spinal canal diameters than females. Stockdale and Finlay (1980) found in their ultrasound based study a decrease in oblique sagittal lumbar spinal dimension from L1 to L3 with an increase caudally.

The transverse diameter of the spinal canal usually demonstrates two peaks in size, one for the cervical spine and another one for the lumbar region. Obviously, these mark the cervical and lumbar enlargements of the spinal cord, which reflect the increased neural tissue demand for the upper and lower limbs. The cervical enlargement is usually broader than the lumbar one (Elsberg and Dyke, 1934; Elliott, 1945; MacLarnon, 1995). Magnuson (1944) gives an average size of the osseous transverse spinal canal diameter of 19 mm at L4 and 12 mm at L5. Berry *et al.* (1987) report for the transverse spinal canal diameter a mild increase caudally, whereas the sagittal diameter did not change from the upper thoracic down to the lower lumbar levels. Aeby (1879) found for both sexes similar trends in transverse spinal canal diameters. He reports a sharp decrease in the most upper cervical spine then mostly a slight increase caudally, with the single exception of the

upper third of the thoracic spine, which shows caudally a decrease in transverse spinal canal size. The transverse diameter of the osseous spinal canal reveals mostly an increase in the cervical spine caudally, with a decrease in size in the upper thoracic spine and generally steady dimensions in the mid-thoracic segment, and a further increase caudally (Panjabi *et al.*, 1991a; Panjabi *et al.*, 1991b; Panjabi *et al.*, 1992). For the low thoracic and lumbar levels the minimal transverse spinal canal shows, according to a study by Marchesi *et al.* (1988), mostly an increase caudally. In their study on recent macerated spines, Postacchini *et al.* (1983) describe a decrease in mid-sagittal neural canal size from L1 to L4 with a slight increase for the last lumbar level. The interpedicular distance shows in general the opposite trend. The value of the above mentioned normal limits for the neural canal size in individuals were doubted by Postacchini *et al.* (1983). Furthermore, two similar ultrasound based studies on the spinal canal dimensions showed significantly different results (Porter *et al.*, 1978a; Legg and Gibbs, 1984). Nevertheless, Hinck *et al.* (1966), based on an X-ray study, provide also normal range values for the interpedicular distance in adults. This particular landmark demonstrates an increase in the middle cervical spine caudally and decreases towards mid-thoracic spine, with a final continuous increase from mid-thoracic to low lumbar levels. Already Elsberg and Dyke (1934) defined and reported normal values for the interpedicular distance of all vertebral levels, as measured on conventional X-ray films. They describe a similar pattern of normal interpedicular morphology, as did Hinck *et al.* (1966). Furthermore, Gepstein *et al.* (1991) found an increase in lumbar interpedicular distance caudally and also for the mid-cervical spine. According to Eisenstein (1977), the normal interpedicular diameter measures 23 mm in the lumbar spine and shows no noteworthy variation within the lumbar levels.

A decrease in spinal canal dimension from L1 caudally was reported in another ultrasound study by Macdonald *et al.* (1984), with a slight increase for the last lumbar level. The values were slightly different in symptomatic individuals with another decrease in size for the last lumbar level (Stockdale and Finlay, 1980). In a similar study, Legg and Gibbs (1984) found mostly a decrease for the lumbar spinal canal dimension caudally. Williams (1975) explored the pathologic narrow lumbar spinal canal relative to the vertebral body size at the same level, with a ratio of 1/6 or 1/6.5 to be defined as being pathologic. The major spinal canal dimensions were investigated by Scoles *et al.* (1988) for both sexes on selected thoraco-lumbar levels in a sample of macerated spines. They describe an increase in sagittal diameter caudally in the thoracic region, followed by a decrease in the upper lumbar and another increase in the lower lumbar spinal levels. The transverse diameter, as described in the study by Scoles *et al.* (Scoles *et al.*, 1988) shows also similar for both sexes a decrease in size in the upper thoracic spine with an increase caudally in the lower thoracic and lumbar spine. For the lumbar spinal canal, Huizinga *et al.* (1952) found an increase in interpedicular width only for the last lumbar level, whereas the antero-posterior spinal canal dimension shows a decrease from L1 to L3 with a slight increase further caudal. A significant relation between these two vertebral canal dimensions are found only for L3 and L4 (Huizinga *et al.*, 1952). Kikuchi *et al.* (1977) describe for the sagittal diameter of the lumbar spinal canal a decrease caudally of L1 with a subsequent increase for the last two lumbar levels, whereas the interpedicular canal shows a steady increase caudally. Larsen and Smith (1980a) found a decrease in size for the mean sagittal diameter from L1 to L4 with an increase for the last lumbar level, whereas the transverse diameter showed a steady decrease in size in the lumbar spine caudally. The lumbar subarachnoid space, according to them, was the smallest in sagittal

direction at L4. As Larsen and Smith (1980a) pointed out, the subarachnoid space consists mostly of blood vessels and loose tissue and measures 1 to 3 mm. Clark *et al.* (1985) mention a significant correlation of the two main spinal canal diameters at thoracic and lumbar levels in two historic samples.

Critical values of spinal canal dimensions are reported in various studies. Epstein *et al.* (1964) mention a sagittal diameter of less than 13 mm to be of pathologic value. If so, the condition was often accompanied by short and bulky pedicles and massive neural arches (Epstein *et al.*, 1964). Similar critical values for X-ray measurements are mentioned by Wolf *et al.* (1956). In a clinical study, Porter *et al.* (1987) group patients in two samples, based on their 15° oblique sagittal spinal canal diameter on L1, with the very narrow ones being below 14.1 mm and the very wide ones being above 15.8 mm. The averages for these two particular groups were 13.8 mm and 16.4 mm, respectively. In other ultrasound based studies, Porter *et al.* (1978b; 1980) report data of the normal sagittal lumbar spinal canal diameter. They found a decrease in 15° oblique size from L1 to L4 with another increase at L5, consistent for both sexes, but in general slightly bigger for females. They mention the cut-off point in oblique sagittal neural canal diameter for people at clinical risk as being 14 mm. Eisenstein (1977) declares as lower limits of the interpedicular distance a width of 18 mm, whereas the normal width, according to him, seems to be 23 mm. Eisenstein (1980) further reports in another study that the trefoil shape of the lumbar spinal canal is mainly caused not by osteophytic overgrowth but rather by a local thickening of the laminae. Wolf *et al.* (1956) mention a minimal sagittal diameter of the cervical spinal canal of 10 mm, based on X-ray assessments, to avoid clinical symptoms in form of spinal cord compression. Eisenstein (1977) states for the sagittal lumbar vertebral foramen diameter values of 13 mm and 16 mm, respectively.

Larmon (1944) mentions as average size for the intervertebral foramen width in cadavers of 7 mm, similar to the mid-sagittal diameter of the vertebral canal, whereas the transverse diameter of the vertebral canal was in his sample on average 12 mm. Kirkaldy-Willis *et al.* (1982) list 4 mm as a borderline for the lumbar intervertebral foramen width as measured on CT scans. Hasegawa *et al.* (1995) declare a posterior disc height of 4 mm and a foraminal height of 15 mm as crucial minimal limits.

The cross-sectional area of the lumbar spine was calculated in a cadaver study by Hasue *et al.* (1983). For the osseous and non-osseous dimensions of the spinal canal in males, the largest value was found at L5, with the smallest being at mid-lumbar, whereas no such trend was found in females. The mean areas of the neural tissue become smaller in caudal direction for both sexes, with the single exception of an increase at L5 in females (Hasue *et al.*, 1983; Kikuchi *et al.*, 1984). According to Hasue *et al.* (1983) and Kikuchi *et al.* (1984), males have larger osseous and non-osseous dimensions, except at L5, but have smaller neural tissue sizes than females. Similar trends can be found for the relation between spinal nerve and the osseous and non-osseous intervertebral foramen size (Hasue *et al.*, 1983; Kikuchi *et al.*, 1984). The lumbar spinal canal, at least as reported for symptomatic subjects (Porter *et al.*, 1978b), shows side differences in its 15° oblique diameter, varying between 0.4 mm at L1 and 0.7 mm at L4.

The pedicle size increases in humans in the lower thoracic spine caudally, decreases slightly in the upper lumbar part and shows another but even stronger increase towards the caudal end of the lumbar spine (Shapiro, 1993). The most striking enlargement of pedicle sizes occurs between the second last and the final lumbar vertebra with an average increase of 73% (Shapiro, 1993). Human pedicle size, as pointed out by Shapiro (1993), is correlated with body size for most lower back levels; unlike pedicle

shape, which is defined as the ratio of pedicle width to pedicle length. The pedicle height, as described for a sex pooled cadaveric sample by Tominaga *et al.* (1995), shows an increase from C3 to C4, with a decrease caudally and another increase in the last cervical level. Zindrick *et al.* (1987) found, in their radiological cadaver study, for the pedicle length an increase in the thoracic spine to Th11 and a decrease caudally. Krag *et al.* (1988) in a similar study, report that the pedicle length decreases from Th9 caudally. Misenhimer *et al.* (1989) describe a decrease in pedicle height caudally for the upper thoracic levels with an increase through Th12. The lumbar levels show a similar pattern, as do the thoracic, with a decrease in size for the upper part and an increase for the lower levels (Misenhimer *et al.*, 1989). Furthermore, Misenhimer *et al.* (1989) state that the thoraco-lumbar pedicles have a teardrop-shape with the widest part in the inferior half. Saillant (1976) describes an increase in pedicle height from C7 caudally, most prominent for the upper thoracic and the most lower thoracic spine, with a caudal decrease in size for the majority of the lumbar levels. Ebraheim *et al.* (1997) found predominantly a slight decrease caudally in pedicle height for the mid-cervical spine in both sexes. For the cervical pedicle width Karaikovic *et al.* (1997) found generally an increase in size caudally. In a study on the pedicle dimensions in an Indian population, Mitra *et al.* (2002) report a decrease in pedicle length from L1 to L4 with a size increase at L5, with females having non-significantly larger values in general. Olsewski *et al.* (1990) found for males a decrease in size of the pedicle height from L1 to L2 with an increase caudally. Females showed a decrease caudally of L1 with only an increase in size for the last lumbar level (Olsewski *et al.*, 1990). The pedicle angle, as measured in relation to the sagittal axis, increases especially in the lower lumbar spine (Krag *et al.*, 1988). Scoles *et al.* (1988) report for both sexes an increase in maximum pedicle diameter caudally for most of the

thoracic levels, with a decrease in size in the upper lumbar region. They found the overall largest values for the maximum pedicle diameter on the lowest lumbar level. Vaccaro *et al.* (1995) describe mostly a slight increase in mid-lower thoracic pedicle height caudally, similar to the findings by Hou *et al.* (1993). Vaccaro *et al.* (1995), furthermore, describe a decrease caudally in the lumbar spine, with a sharp increase in pedicle height for the last lumbar level. The pedicle height, as measured on all levels and bilaterally by Panjabi *et al.* (1991a; 1991b; 1992), shows in general a decrease in size caudally in the upper cervical, mid-thoracic and upper- / mid-lumbar spine, whereas an increase caudally can be found in the other spinal regions. The highest values are reported for level L5 (Panjabi *et al.*, 1992).

The particular anatomy of the dural sac, the shape of the dural sheath at lumbar levels and the lumbo-sacral nerve roots, have been widely addressed by Salamon *et al.* (1966). The size of the subarachnoid space in the lumbar spine of symptomatic and asymptomatic individuals has also already been addressed (Larsen and Smith, 1980a).

The lordosis of the cervical spine is, according to Jankauskas (1994), only caused by the intervertebral discs, whereas the lumbar one is formed by the discs as well as the vertebral bodies` shape. The lumbar lordosis was to be found more prominent in females and in individuals of greater body weight (Murrie *et al.*, 2003).

The size of lumbar intervertebral foramen is usually the biggest for L5 / S1, whereas L1 / L2 have the smallest area (Stephens *et al.*, 1991). Putti (1927) describes the opposite, with the L5/S1 intervertebral foramen being the smallest and lists as a rule that the more cranially located, the bigger the lumbar foramen is supposed to be. On the other hand, Putti (1927) mentions the contrary for the nerve root size, with L5 being the largest, and the more cranial one being smaller in size. Kirkaldy-Willis *et al.* (1982) list,

independent of the vertebral level, an average of 4 mm as a borderline for the intervertebral foramen width, as measured by CT. Ebraheim *et al.* (1996) reported the dimensions of the cervical intervertebral foramen in cadaver and macerated specimens. They divided the cervical intervertebral foramen in three parts, a medial pedicle section, the middle section next to the foramen transversarium, and finally, a most lateral part. Except for the first level at C2 / C3, all other cervical levels showed, according to Ebraheim *et al.* (1996) an increase in size caudally. The minimum intervertebral foramen width was 1-2 mm at all levels.

The weight of the dry human spine differs by region and sex. According to Trotter and Hixon (1974), the cervical, thoracic and lumbar vertebrae of White adults weigh approximately 53 g, 131 g, 112 g for males and for females 39 g, 98 g, and 81 g, respectively. The relative weight of the axial postcranial skeleton, consisting for this analysis of the vertebral column, ribs and sternum, decreases mostly in adulthood in both sexes, and is on average 18% of the total adult skeleton weight (Trotter and Hixon, 1974). Additionally, Trotter and Hixon (1974) found that males show higher mean bone densities in all spinal parts.

Impact of osteometric research of the human spine

Spinal osteometric data can be applied for various purposes. They help e.g., to estimate stature, since the size, weight and volume of the spine are usually correlated with individual height in humans (Hasebe, 1913; Martin, 1928; Latimer, 1950; Martin and Saller, 1957; Fully and Pineau, 1960; Tibbetts, 1981; Jason and Taylor, 1995). Nevertheless, in the osteometric study by Berry *et al.* (1987) the size of the combined vertebral body heights did not correlate with the individual body height at autopsy.

Furthermore, morphometric studies of the osseous vertebral column help to define gold-standards for subsequent clinical applications (Saillant, 1976; Kikuchi *et al.*, 1977; Postacchini *et al.*, 1983; Nissan and Gilad, 1984; Gilad and Nissan, 1986; Berry *et al.*, 1987; Zindrick *et al.*, 1987; Krag *et al.*, 1988; Marchesi *et al.*, 1988; Scoles *et al.*, 1988; Misenhimer *et al.*, 1989; Olsewski *et al.*, 1990; Black *et al.*, 1991; Panjabi *et al.*, 1991a; Panjabi *et al.*, 1991b; Panjabi *et al.*, 1992; Hermann *et al.*, 1993; Hou *et al.*, 1993; Vaccaro *et al.*, 1995; Xu *et al.*, 1995; Kothe *et al.*, 1996; Ebraheim *et al.*, 1997; Karaikovic *et al.*, 1997; Mitra *et al.*, 2002) or they can proof the suitability of animal models in relation to the human spinal dimensions (Cotterill *et al.*, 1986; Tominaga *et al.*, 1995). Panjabi *et al.* (1992) declare their study on the three-dimensional vertebral morphometry to be useful as a "blueprint", which can be implied in clinical issues or in mathematical analysis of the spine. Furthermore, Scoles *et al.* (1988) emphasize the fact that the knowledge of spinal morphometry is still limited, despite its need for orthopaedic implant assessments. For example, Scoles *et al.* (1988) and a similar study undertaken by Berry *et al.* (1987) disagree on the minimum pedicle dimensions, which would have a crucial impact on the use of transpedicular fixation screws. In their study on Indian populations, Mitra *et al.* (2002) also found pedicle values different from earlier published ones, which led them e.g., to recommend specific screw dimensions to be used in chirurgical approaches. Similar observations are reported for the non-White sample examined by Hou *et al.* (1993), which showed in general smaller pedicle dimensions than earlier reported standards.

A list of performed earlier major osteometric studies could be found in Table 1, whereas morphological studies on cadaveric samples and living individuals are listed in Table 2.

Table 1: Osteometric studies of recent and historic spine samples

Reference	Time Period	N	Method	Spinal region
Aeby (1879)	Late 19th century	13	Scale	All
Amonoo-Kuofi (1985)	Recent	92	Caliper	Lumbar
Anderson (1883)	Late 19th century	53	Ruler	All
Berry *et al.* (1987)	Late 19th / Early 20th century	1	Caliper?	All
Boszczyk *et al.* (2001)	Recent	106	Anthropometer	All
Clark *et al.* (1985)	10th-13th century	? / 95	Caliper	All
Cotterill *et al.* (1986)	Recent	10	Caliper	Th6, Th12 and L3
Cwirko-Godycki and Swedborg (1977)	13th century	48	Caliper	C1 / C2
Cyriax (1920)	Early 20th century	Ca 70	?	All
Davis (1961)	Mid 20th century	201	Caliper	All
Dommisse (1974; 1975)	Recent	6 / 25	Caliper	Thoracic and lumbar
Ebraheim *et al.* (1996)	Recent	443	Caliper	Lumbar
Ebraheim *et al.* (1997)	Recent	40	Caliper	Cervical
Eisenstein (1977)	Late 19th / Early 20th century	338	Caliper?	L3 / L4
Ericksen (1976)	Late 19th / Early 20th century	3-4	Caliper / clay casts	Lumbar
Francis (1955)	Mid 20th century?	284	Caliper	Cervical
Frey (1929)	Early 20th century	150	Measurement tape	All
Fully and Pineau (1960)	Mid 20th centruy	164	?	All
Gepstein *et al.* (1991)	Recent	54	Caliper	Cervical and lumbar
Hasebe (1913)	Early 20th century	30	Measurement tape	All
Hou *et al.* (1993)	Recent	40	Caliper	Th9-L5
Huizinga *et al.* (1952)	19th century	51	Caliper	Lumbar
Jacobi (1927)	Early 20th century	102	Ruler	Th1-L3
Jankauskas (1994)	1st / 2nd Millennium A.D.	539	Caliper	All
Kaliszewska (1966)	12th century	1	Caliper	All

Kanziora *et al.* (2001)	Recent	20	Digital ruler	Cervical
Karaikovic *et al.* (1997)	Recent	53	Caliper / CT	Cervcical
Kikuchi *et al.* (1977)	Recent	80	Caliper	Lumbar
Lanier (1939)	Recent	30	Caliper	Th2, Th7, Th12 and lumbar
Lee *et al.* (1995)	Recent	90	Caliper	Lumbar
Marchesi *et al.* (1988)	Recent	33	Caliper? / X-ray	Th6 – L5
Piontek (1973); Piontek and Budzynska (1972); Piontek and Zaborowski (1973)	12-14th century / 14-18th century	41/ 50	Caliper	Cervical
Porter and Pavitt (1987)	Anglo-Saxon and Roman-British		Photographic	Lumbar
Postacchini *et al.* (1983)	Recent?	121	Caliper	Lumbar
Present study	**Since Late Upper Paleolithic to mid 20th century**	**348**	**Caliper**	**C3, C7, Th1, Th6, Th10, L1, L5**
Putz (1981)	Recent	66?	Scales / Goniometer	All
Ravenel (1877)	Late 19th century	22	Scale	All
Rosenberg (1899)	Late 19th century	5	Compass	Low thoracic and lumbar
Scoles *et al.* (1988)	Late 19th / Early 20th century	50	Caliper	Selected thoracic and lumbar levels
Shapiro (1993)	Recent	42	?	Low thoracic and lumbar
Stefko (1926)	Early 20th century?	54?	?	All
Swedborg (1974)	10th-12th century	91?	Caliper	All
Tatarek (2001)	Prehistoric / recent	90	Caliper	Thoracic and lumbar
Thomson (1913)	Early 20th century	6	Caliper?	All
Todd and Pyle (1928b)	Early 20th century	59	Surface drawing	Lumbar
Tominaga *et al.* (1995)	Recent	6	Caliper	Cervical
Wetzel (1910)	Late 19th / Early 20th century?	16	?	All
Wood-Jones (1938)	Early 20th century?	?	?	C1 / C2
Xu *et al.* (1995)	Recent	56	Caliper	C7

Table 2: Morphological studies of spines in living people and cadavers

Reference	Material	N	Method	Type	Spinal Region
Adams *et al.* (1994)	Cadavers	19	Biomechanical	Dynamic	Lumbar
Banta *et al.* (1989)	Cadavers	16	Caliper / X-ray	Static	Th6 - L5
Davies *et al.* (1989)	Living, asymptomatic women	191	X-ray	Static	Th7 - L4
Diacinti *et al.* (1995)	Living, asymptomatic women	126	X-ray	Static	Thoracic and lumbar
Dommisse (1974; 1975)	Living, asymptomatic	50	X-ray	Static	Thoracic and lumbar
Drinkall *et al.* (1984)	Asymptomatic and symptomatic	386	Ultrasound	Static	Lumbar
Ebraheim *et al.* (1996)	Cadavers	14	Caliper	Static	Cervical
Edmonston *et al.* (1994)	Cadavers of elderly people	18	CT	Static	Thoracic and lumbar
Elsberg and Dyke (1934)	Asymptomatic / symptomatic	100 / 86	X-ray	Static	All
Fujiwara *et al.* (2001)	Cadavers	39	CT / biomechanical	Dynamic	Lumbar
Gallagher and Hedlund (1988)	Living, asymptomatic women	150	X-ray	Static	Th3 - L5
Gozdziewski *et al.* (1976)	Living, asymptomatic	776	Anthropometric	Static	Thoraco-lumbar
Harrington *et al.* (2001)	Living, symptomatic and asymptomatic	72	CT	Static	L4 / L5 only
Hasegawa *et al.* (1995)	Cadavers	18	Photographic measurements	Static	Lumbar
Hedlund and Gallagher (1988)	Living, symptomatic women	153	X-ray	Static	Thoracic and lumbar
Hermann *et al.* (1993)	Living, asymptomatic	113	X-ray	Static	Mid-thoracic and lumbar
Hinck *et al.* (1966)	Living, no obvious pathology	121	X-ray	Static	All
Horner (1854)	Cadaver / living, asymptomatic	4? / 1?	Ruler?	Static / Dynamic	All
Humphreys *et al.* (1998)	Living, asymptomatic and symptomatic	43	MRI	Static	Cervical

Hurxthal (1968)	Living, asymptomatic women	20	X-ray	Static	Th7 - L5
Inufusa *et al.* (1996)	Cadavers	37	CT	Static and dynamic	Lumbar
Jason and Taylor (1995)	Cadavers	167	Flexible ruler	Static	All
Katz *et al.* (1975)	Living, asymptomatic	61	X-ray	Static	Cervical
Kothe *et al.* (1996)	Cadavers	14	X-ray	Static	Selected thoracic levels
Krag *et al.* (1988)	Living, symptomatic	41	CT	Static	T9 - L5
Larsen and Smith (1980a; 1980b)	Symptomatic and asymptomatic	83	X-ray / Myelography	Static	Lumbar
Legg and Gibbs (1984)	Living, asymptomatic males	50	Ultrasound	Static	Lumbar
Lu *et al.* (2000)	Cadavers	16	Computer-assisted photographic simulation	Dynamic	Cervical
Macdonald *et al.* (1984)	Living, symptomatic and asymptomatic	204	Ultrasound	Static	Lumbar
Magnuson (1944)	Cadavers	10	Caliper?	Static	Lumbar
Mayoux-Benhamou *et al.* (1989)	Cadavers	7	Caliper / Cast	Dynamic	Lumbar
Minne *et al.* (1988)	Living, asymptomatic	110	X-ray	Static	Mid- and low-thoracic and lumbar
Misenhimer *et al.* (1989)	Cadavers	6	Caliper / CT	Static	Thoracic and lumbar
Mitra *et al.* (2002)	Cadavers	20	Caliper, X-ray and CT	Static	Lumbar
Nissan and Gilad (1984; 1986)	Living, asymptomatic	157	X-ray	Static	Cervical and lumbar
Nowicki *et al.* (1996)	Cadavers	31	CT/ MRI	Dynamic	Lumbar
Olsewski *et al.* (1990)	Cadavers, living symptomatic	100	Caliper / X-ray, CT	Static	Lumbar
Panjabi *et al.* (1983)	Cadavers	12?	Biomechanical	Dynamic	Lumbar
Panjabi *et al.* (1991a)	Cadavers	12	Biomechanical	Dynamic	Cervical
Panjabi *et al.* (1991b)	Cadavers	12	Biomechanical	Dynamic	Thoracic
Piera *et al.* (1988)	Living, symptomatic	215	X-ray	Static	Lumbar
Piontek and Zaborowski (1973)	Living patients	185	X-ray	Static	Cervical

Porter *et al.* (1978a)	Living, asymptomatic and symptomatic	273	Ultrasound	Static	Lumbar
Porter *et al.* (1980)	Living, asymptomatic and symptomatic	550?	Ultrasound	Static	Lumbar
Ross *et al.* (1991)	Living, asymptomatic women	1098	X-ray	Static	Thoracic and lumbar
Saillant (1976)	Cadavers	35	Caliper?	Static	Thoracic and lumbar
Schmid *et al.* (1999)	Living, asymptomatic	12	MRI (open)	Dynamic	Lumbar
Stephens *et al.* (1991)	Cadavers	20	Molding technique and X-ray	Static	Lumbar
Stockdale and Finlay (1980)	Asymptomatic and symptomatic	+/- 100	Ultrasound	Static	Lumbar
Tibbetts (1981)	Cadavers	200	Caliper	Static	All
Ullrich *et al.* (1980)	Living, asymptomatic	60	CT	Static	Lumbar
Vaccaro *et al.* (1995)	Cadavers, asymptomatic patients	36	Caliper, CT	Static	Mid- / Lower thoracic
Van Schaik *et al.* (1985)	Living, symptomatic	123	CT	Static	L3 - L5
Weisz and Lee (1983)	Living, symptomatic	75	CT	Static	Low lumbar
Wildermuth *et al.* (1998)	Living, symptomatic	30	MRI, Myelography	Dynamic	Lumbar
Williams (1975)	Living, symptomatic	100	Myelography	Static	L3 - L5
Wolf *et al.* (1956)	Living, asymptomatic	200	X-ray	Static	Cervical
Zindrick *et al.* (1987)	Cadavers	522-628	X-ray and CT	Static	Thoracic and lumbar

The study of the bony outline of the lumbar spinal canal allows drawing limited conclusions about the size of the dural sac in the particular individual, since these two measurements are mostly well correlated (Larsen and Smith, 1980a). The measured osseous spinal canal dimensions may at least partially reflect the outline of its neural content. Spinal canal dimensions correlate well with spinal cord size in primates (MacLarnon, 1995; MacLarnon, 1996a). MacLarnon (1995) found that the white matter size, unlike the grey matter dimensions of the spinal cord, correlates with the osseous spinal canal dimensions. MacLarnon (1995) links partially the found differences of the spinal canals in various primates with their particular fore- and hind-limb innervation.

Therefore, if one finds an alteration of the osseous spinal outline this may have various functional implications as well. MacLarnon (1995) interprets the larger dimensions in more dominant limbs is more likely due to more or thicker nervous fibres instead of higher numbers of nerve cells. Whatever the underlying factor, such as increased myelination of fibres or more branched nervous fibres, an apparent increase of neural transmission speed of more developed limb innervation is visible in an altered white matter pattern and, following, the osseous dimensions of the vertebral column (MacLarnon, 1995). MacLarnon (1995) also found that any increased neuronal demand in a limb is more reflected in a more prominent development, within the spinal cord white matter, of the dorsal rather than the latero-ventral columns. This finding was interpreted by MacLarnon (1995) as a reflection of a possible higher proprioceptive demand rather than in numbers of motor neurons. Any increased neuronal supply in a limb seems, therefore, to be mainly influencing the sensory and fibrous part of the spinal cord and, therefore, be also present in an increased number of sensory neurons, to be found in the dorsal root ganglion that plays a crucial part in the etiology of lower back pain not in an

altered motor neuronal supply. Lassek and Rasmussen (1938) interpret the high variability of white spinal cord matter cross-sectional area as a result of inter-individual differences in fibre size and number. Spinal cord weight shows no clear correlation with locomotion pattern at least in primates (MacLarnon, 1996b). Surprisingly, the white matter seems to be more sensitive than the grey matter to such locomotive alterations. Humans have a higher amount of such white matter in their lumbar spinal enlargement than predicted for their body weight (MacLarnon, 1996b). It is well known that the number of neurons and the size of central nervous tissue decrease with age (Dunn, 1912). Earlier studies also showed a notable decrease of the myelinated spinal nerve root fibres with age (Dunn, 1912; Corbin and Gardner, 1937). Furthermore, it is also well known that muscle mass, represented by robusticity in skeletal specimens, influences the number and size of nerve fibres (Dunn, 1912). For example, the size of the spinal cord and brain parts are positively influenced in growing cats undergoing physical training (Agduhr, 1917), at least for the regions that are innervating the trained muscles. Additionally, Dunn (1912) reports for albino rats a correlation of size and number of cervical nerve root fibres with increased weight, but also with age to a certain point, before the senile fibre size decrease start. Furthermore, he suggests a correlation between nerve root calibre and size of tissue innervated. Corbin and Gardner (1937) also found such a clear correlation between muscle mass and number of ventral root fibres in the spinal column of selected individuals.

Spinal pathologies - especially lower back pain

The vulnerability of the human back produces various neurological and orthopaedic pathologic conditions (Simmonds, 1903; Bailey and Casamajor, 1911;

Willis, 1924; Jacobi, 1927; Putti, 1927; Willis, 1929; Blumensaat and Clasing, 1932; Philipp, 1932; Samuel, 1932; Junghanns, 1933; Larmon, 1944; Magnuson, 1944; Brain, 1948; Pallis *et al.*, 1954; Verbiest, 1954; Gill and White, 1955; Nathan *et al.*, 1960; Roaf, 1960; Epstein *et al.*, 1962; Burrows, 1963; Epstein *et al.*, 1964; Hurxthal, 1968; Jones and Thomson, 1968; Dommisse, 1974; Swedborg, 1974; Veleanu, 1975; MacGibbon and Farfan, 1979; Ciric *et al.*, 1980; Park, 1980; Crock, 1981; Kirkaldy-Willis *et al.*, 1982; Dorwart *et al.*, 1983; Ogino *et al.*, 1983; Louis, 1985; Resnick, 1985; Gaskill *et al.*, 1991; Jankauskas, 1992; An and Glover, 1994). Furthermore, one has to remember that the occurrence of some spinal pathologies are inter-correlated with each other (Swedborg, 1974).

Low back pain and other severe clinical symptoms, such as radiculopathy, are extremely common (Brown, 1975; Kelsey and White, 1980; Macdonald *et al.*, 1984; Hartvigsen *et al.*, 2001; Stebler *et al.*, 2001) and cause enormous socio-economic costs in modern societies (Macdonald *et al.*, 1984; Gaskill *et al.*, 1991; Maniadakis and Gray, 2000). Therefore, approaches to determine their possible etiologies are numerous (Bailey and Casamajor, 1911; Willis, 1924; Putti, 1927; Willis, 1929; Blumensaat and Clasing, 1932; Philipp, 1932; Mixter and Barr, 1934; Larmon, 1944; Magnuson, 1944; Brain, 1948; Huizinga *et al.*, 1952; Pallis *et al.*, 1954; Gill and White, 1955; Epstein *et al.*, 1962; Burrows, 1963; Epstein *et al.*, 1964; Nachemson, 1966; Salamon *et al.*, 1966; Jones and Thomson, 1968; Brown, 1975; Ramani, 1976; Eisenstein, 1977; Kikuchi *et al.*, 1977; Porter *et al.*, 1978a; MacGibbon and Farfan, 1979; Nachemson *et al.*, 1979; Ciric *et al.*, 1980; Eisenstein, 1980; Larsen and Smith, 1980a; Larsen and Smith, 1980b; Porter *et al.*, 1980; Crock, 1981; Hasue *et al.*, 1983; Ogino *et al.*, 1983; Panjabi *et al.*, 1983; Weisz and Lee, 1983; Jungers, 1984; Kikuchi *et al.*, 1984; Macdonald *et al.*, 1984; Rydevik *et al.*,

1984; Vanderlinden, 1984; Clark *et al.*, 1985; Weinstein, 1986; Heliövaara, 1987; Porter *et al.*, 1987; Porter and Pavitt, 1987; Rauschning, 1987; Hoyland *et al.*, 1989; Mayoux-Benhamou *et al.*, 1989; Yoo *et al.*, 1992; Yoshida *et al.*, 1992; Ebraheim *et al.*, 1996; Nowicki *et al.*, 1996; Leboeuf-Yde *et al.*, 1997; Schmid *et al.*, 1999; Fujiwara *et al.*, 2001; Harrington *et al.*, 2001; Hartvigsen *et al.*, 2001; Cinotti *et al.*, 2002; Al Faraj and Al Mutairi, 2003; Murrie *et al.*, 2003) and the clinical and diagnostic impact of low back pain has been described for more than one hundred years, as already reviewed earlier (Dyck, 1984; Rüttimann, 1990; Wiltse, 1991; An and Glover, 1994).

Various radiological techniques, such as conventional X-ray, ultrasound, myelography or CT-scanning, can be used in clinical situations to address the size of the neural pathways and vertebral bodies (Burrows, 1963; Hurxthal, 1968; Williams, 1975; Ramani, 1976; Porter *et al.*, 1978a; Porter *et al.*, 1978b; Larsen and Smith, 1980a; Park, 1980; Porter *et al.*, 1980; Stockdale and Finlay, 1980; Hibbert *et al.*, 1981a; Kirkaldy-Willis *et al.*, 1982; Legg, 1982; Weisz and Lee, 1983; Drinkall *et al.*, 1984; Legg and Gibbs, 1984; Macdonald *et al.*, 1984; Bolender *et al.*, 1985; Gallagher *et al.*, 1988; Hedlund and Gallagher, 1988; Minne *et al.*, 1988; Davies *et al.*, 1989; Schmid *et al.*, 1999) or pedicle dimensions (Zindrick *et al.*, 1987; Krag *et al.*, 1988; Marchesi *et al.*, 1988; Banta *et al.*, 1989; Misenhimer *et al.*, 1989; Olsewski *et al.*, 1990; Hou *et al.*, 1993; Vaccaro *et al.*, 1995; Kothe *et al.*, 1996; Ebraheim *et al.*, 1997; Karaikovic *et al.*, 1997; Mitra *et al.*, 2002). Lumbar spine imaging counts for approximately 4% of all X-ray facility workloads (Park, 1980), with a lot of them dealing with lower back pain issues.

Imaging data, gained even with most sophisticated techniques such as advanced CT-scanning and MRI, differ slightly from data obtained *in situ*. Black *et al.* (1991) and Hermann *et al.* (1993) remind that morphological measurements obtained from

conventional radiographs may differ depending on the positioning of measuring landmarks. Jones and Thomson (1968) recommend, based on their experience in clinical cases, the use of the vertebral canal to vertebral body ratio in plain X-rays as a supplementary aid. This recommendation was followed in various studies e.g., in a myelographic study on the narrow lumbar spinal canal by Williams (1975) or in an osteometric study by Kikuchi *et al.* (1977). No difference between pedicle measurements obtained by either conventional X-ray or CT scanning was found by Zindrick *et al.* (1987), a statement mostly supported by Krag *et al.* (1988) too. Karaikovic *et al.* (1997) also mentioned that there is no relevant difference between caliper based measurements and CT data of the same spinal structure. Mitra *et al.* (2002) found slightly different values of various pedicle dimensions for X-ray and CT-scanning in comparison to direct measurements, similar to Misenhimer *et al.* (1989); whereas Marchesi *et al.* (1988) did not found any significant difference. Olsewski *et al.* (1990) report mostly significant differences between osteometric and X-ray measurements of various lumbar pedicle dimensions.

Spinal stenosis is a clinical syndrome, which originates from a narrowing of the spinal canal, the lateral recess or the neural foramen as a result of bony and / or soft tissue alterations (Bailey and Casamajor, 1911; Putti, 1927; Larmon, 1944; Magnuson, 1944; Brain, 1948; Pallis *et al.*, 1954; Verbiest, 1954; Epstein *et al.*, 1962; Burrows, 1963; Epstein *et al.*, 1964; Arnoldi *et al.*, 1976; Kikuchi *et al.*, 1977; Porter *et al.*, 1978a; Porter *et al.*, 1980; Crock, 1981; Kirkaldy-Willis *et al.*, 1982; Dorwart *et al.*, 1983; Hasue *et al.*, 1983; Ogino *et al.*, 1983; Postacchini *et al.*, 1983; Weisz and Lee, 1983; Bose and Balasubramaniam, 1984; Kikuchi *et al.*, 1984; Rydevik *et al.*, 1984; Vanderlinden, 1984;

Bolender *et al.*, 1985; Rauschning, 1987; Lee *et al.*, 1988; Hoyland *et al.*, 1989; An and Glover, 1994; Nowicki *et al.*, 1996; Fujiwara *et al.*, 2001).

Radiological abnormalities of the cervical spine can be found frequently and in general more commonly in men (Pallis *et al.*, 1954). Roughly, 75% of the individuals aged 50 years and above show a narrowing of the spinal canal due to various underlying conditions, such as osteophytes or vertebral subluxation. Surprisingly, in such a sample of individuals without neurological symptoms, a similar fraction of adults showed radiological signs of foraminal narrowing and even more had signs of a narrowed intervertebral disc space or marginal osteophytes on the anterior vertebral body border (Pallis *et al.*, 1954). In an unselected sample of individuals who underwent myelographic imaging, Williams (1975) found a total of 3% narrow lumbar spinal canals. In a Danish longitudinal study assessment, investigated by Hartvigsen *et al.* (2001), it was found that heavy work load is important for the occurrence of low back pain and sedentary work acts protectively. Hartvigsen *et al.* (2001) discussed this result with regard to the "healthy worker effect", which confuses findings of cross-sectional studies on the prevalence of lower back pain, due to the self-selection process of healthier individuals remaining in their job; a bias occurring in form of a migration between possible exposure groups. Heliövaara (1987), as already mentioned above, found a correlation between herniated lumbar intervertebral disc and body height as well as body mass in males.

Classification of the spinal stenosis etiology usually differentiates between the congenital-developmental and the acquired forms (Arnoldi *et al.*, 1976). Most patients are approximately 35-65 years old, with the majority being over 50 years, and express various clinical symptoms and signs such as senso-motoric defects, dysfunction of the bladder, gait instability and radicular pain. A clinical sample of a general practice in rural

England showed a slightly higher, but statistically not significant, frequency of low back pain in males with 54% of all 193 cases and a mean age for patients of 45 years (Drinkall *et al.*, 1984). In a sample investigated by Harrington *et al.* (2001) the average age of symptomatic patients was 43 years for men and 44 years for women, respectively. Nowicki *et al.* (1996) found in a cadaver sample the stenotic intervertebral foramen to be most frequent at L5 / S1, whereas the occult or resolved intervertebral foramen showed no preference within the lumbar vertebral levels. Eisenstein (1977) found in a skeletal sample a total of over 6% with suggested stenosis in at least one of the two main spinal canal diameters.

Major etiologies for spinal stenosis are congenital or degenerative reasons, rather than tumorous conditions or traumatic pathologies. One possibility is disc herniation, which occurs commonly in the lower lumbar spine at the postero-lateral border of the disc and alters the intervertebral foramen size. Pallis *et al.* (1954) describe osteoarthritis to be the main cause of foraminal stenosis.

Neurologic symptoms may be caused either by direct nerve impingement e.g., the nerve root or by compression of adjoining vascular structures (Bailey and Casamajor, 1911; Putti, 1927; Brain, 1948; Dommisse, 1974; Rauschning, 1987; Hoyland *et al.*, 1989; Gaskill *et al.*, 1991). Rydevik *et al.* (1984) propose an etiological model of initial trauma due to e.g., herniated disc, causing oedema and other acute and chronic effects including local ischemia, which finally leads to a dysfunction of the nerve fibres.

These etiologies have been shown in various clinical reports (Bailey and Casamajor, 1911; Putti, 1927; Mixter and Barr, 1934; Brain, 1948; Epstein *et al.*, 1962; Epstein *et al.*, 1964; Jones and Thomson, 1968; Ciric *et al.*, 1980; Kirkaldy-Willis *et al.*, 1982; Dorwart *et al.*, 1983; Ogino *et al.*, 1983; Weisz and Lee, 1983; Vanderlinden,

1984; An and Glover, 1994; Avrahami *et al.*, 1994; Jeanneret and Jeanneret, 2002); since the first report of nerve root compression due to osteoarthritis and in the absence of tumorous or fracture etiology has been published (Bailey and Casamajor, 1911). This early report already highlighted the frequent involvement of the intervertebral foramen in such cases of spinal neural compression. Huizinga *et al.* (1952) label, due to the various *de facto* relative morphological approaches trying to clearly define it, clinical stenosis to be rather a non-absolute concept. The shape and partially size of the vertebral endplate was found to influence the prevalence of herniated intervertebral discs in the low lumbar spinal region (Harrington *et al.*, 2001). Harrington *et al.* (2001) have linked a circularly shaped vertebral endplate, with its increased anular tension forces together with acting force vectors especially in large males, to such pathologies. They did not find a correlation between individual stature, weight or body mass index and the presence of a herniated low lumbar intervertebral disc. Harrington *et al.* (2001) also discuss if an "inherited morphologic factor" may be involved in this etiological puzzle.

A possible etiological influence of the extrinsic vascular supply in the pathogenesis of spondylotic myelopathy was raised by Ogino *et al.* (1983). Brain (1948) argues that the initial alterations by protruded intervertebral discs are of circulatory nature most likely involving the venous system by causing an oedema. The arterial system, according to him, either would be involved indirectly at a later stage or will be implicated directly by mechanical compression due to protrusion or osteoarthritis. Magnuson (1944) mentions inflammation e.g., of the joint capsules and the ligamentum flavum, as a possible cause for lower back pain. Hasue *et al.* (1983) list intraneural fibrosis of the spinal nerve roots and ossifications of the ligamenta flava and posterior longitudinal ligaments as further possible etiologies causing lower back pain and radicular symptoms.

Kikuchi *et al.* (1984) already studied the pathophysiology of radicular pain. They discuss, based on clinical as well as cadaveric cases, a plethora of possible etiologies of congenital, acquired, or both combined backgrounds. Vanderlinden (1984) reports selected clinical cases of compression of the dorsal root ganglion causing sciatic pain. Rauschning (1987) mentions disc bulging, altered ligamentum flavum and degeneratively changed facet joints as main contributors in narrowed lumbar root canals, similar to the reported findings by Nowicki *et al.* (1996). Putti (1927) highlights the mismatch in size between the intervertebral foramen and the exiting nerve root, making especially the lowest lumbar levels vulnerable to clinical conditions. Hoyland *et al.* (1989) propose the hypothesis that venous obstruction e.g., due to a herniated disc, may cause periradicular fibrosis and subsequently clinical symptoms. This is similar to an etiological multifactor model proposed by Rydevik *et al.* (1984). Already Gill and White (1955) reported the etiological connection between the presence of a transitional last lumbar vertebra and the occurrence of lower back pain. Also MacGibbon and Farfan (1979) found a link between the presence factors such as a transitional lumbar vertebra, rudimentary ribs or size of transverse process and lower lumbar degeneration. The shape of the lumbar vertebral endplate was found to be linked with disc herniation (Harrington *et al.*, 2001). Metabolic etiologies, such as Vitamin D deficiency (Al Faraj and Al Mutairi, 2003), correlate with lower back pain as well.

Various reports already examined the possible morphologic difference between healthy and pathologic individuals with regard to lower back pain. Drinkall *et al.* (1984) report a significant difference of the sagittal spinal canal diameter for patients with lower back pain and control groups, with the former one having narrower values. Stockdale and Finlay (1980) also found in their ultrasound based study differences between

asymptomatic and symptomatic individuals with the latter ones having a narrower oblique sagittal diameter at L5. Larsen and Smith (1980a; 1980b) did not report in a myelographic study any altered lumbar vertebral body diameters in lower back pain patients in comparison to a neutral control group, making the involvement of spinal canal size changes to be found in such clinical case independent of the main vertebral body dimensions. In contrast, Ramani (1976) describes differences in vertebral canal / vertebral body ratio between asymptomatic and symptomatic individuals in an X-ray based study. Porter *et al.* (1980) emphasise in their ultrasound study that the size of the spinal canal is more crucial in cases of disc symptomatology and neurogenic claudicatio than in classic root entrapment syndrome. Stephens *et al.* (1991) found a change in intervertebral foramen size from either round or auricular in shape to being more of auricular and teardrop shape in cases of spinal pathologies; see also Figure 1.

Foraminal stenosis is defined as the narrowing of the bony exit of the nerve root Patients may have radicular pain with or without sensori-motor findings and symptoms usually exacerbated with extension movements of the spine (Yoo *et al.*, 1992; Inufusa *et al.*, 1996; Humphreys *et al.*, 1998; Chung *et al.*, 2000). These radiculopathies are caused, among others, by ischemia or direct nerve root impingement (Ciric *et al.*, 1980; Kirkaldy-Willis *et al.*, 1982; Resnick, 1985; Group and Stanton-Hicks, 1991). Hoyland *et al.* (1989) link the mechanical obstruction of the intervertebral foramen venous plexus the subsequent ischemic related periradicular fibrosis, which would finally cause clinical symptoms.

The quantitative and qualitative assessment of the influence of static and dynamic body positions on the dural sac and the intervertebral foramina has been reported for various radiographic techniques (Verbiest, 1954; Epstein *et al.*, 1964; Salamon *et al.*,

1966; Jones and Thomson, 1968; Park, 1980; Kirkaldy-Willis *et al.*, 1982; Vital *et al.*, 1983; Weisz and Lee, 1983; Bolender *et al.*, 1985; Liyang *et al.*, 1989; Nowicki *et al.*, 1996; Wildermuth *et al.*, 1998; Chung *et al.*, 2000; Fujiwara *et al.*, 2001). A correlation between the collapse of the intervertebral disc height and its possible clinical symptoms has already been shown as well (Hasegawa *et al.*, 1995; Lu *et al.*, 2000). Nevertheless, Cinotti *et al.* (2002) doubt the alteration by a narrowing of the disc space and the intervertebral foramen width reduction. According to them, it influences mainly the height, whereas the intervertebral foramen width is mostly correlated with the sagittal diameter of the spinal canal and the pedicle length. Nowicki *et al.* (1996) emphasise the fact that an abnormal intervertebral disc is significantly correlated with stenotic foramen in the lumbar cadaver spine. Salamon *et al.* (1966) link the acute nerve root pain rather to herniated discs compromising the fossa below the nerve root than to the inflammation of the root itself.

Clinical and dynamic assessment of the spinal neural pathways

No exact characteristics exist, which mark the transition from asymptomatic to symptomatic in the spine (Wolf *et al.*, 1956; Burrows, 1963; Postacchini *et al.*, 1983; Porter *et al.*, 1987; Humphreys *et al.*, 1998). Clinical evaluations of the osseous spinal neural pathways have been reported in a plethora of studies. One of the changes to be associated with spinal stenosis seems to be inferior facet hypertrophy, with the major changes occurring in the middle of the intervertebral foramen (Humphreys *et al.*, 1998). According to Humphreys *et al.* (1998) the spinal nerve is forced, due to this inferior facet hypertrophy to the superior, more frequently, or to the inferior part of the foramen. Since these foramen areas are small, nerve compression and, consequently, clinical symptoms

can occur. Kirkaldy-Willis *et al.* (1982) stress the fact that the exiting spinal nerve root is especially vulnerable while passing below the pedicle, while Putti (1927) emphasises the finding that the most lower lumbar levels are particularly susceptible to such a neural entrapment. The particular anatomy of the cervical spine in relation to possible pathologies involving neural pathways has already been addressed by Veleanu (1975), whereas Crock (1981) and Bose and Balasubramaniam (1984) addressed it for the lumbar spine.

As one example, the inter-individual variability of the transverse spinal canal diameter varies, apparently mostly depending on vertebral level rather than age or sex (Hinck *et al.*, 1966). From a clinical perspective, the interpedicular distance increases in cases of spinal tumors (Elsberg and Dyke, 1934), whereas Drinkall *et al.* (1984) found smaller values of lumbar sagittal spinal canal dimensions for lower back pain sufferers than for control groups. Similar are the findings for a coal miners sample, as presented by Macdonald *et al.* (1984), where smaller spinal canal diameters were correlated with higher lower back pain morbidity. Additionally, in an ultrasound study by Porter *et al.* (1978a) the symptomatic individuals showed significantly smaller oblique sagittal spinal canal diameters than the asymptomatic ones. But, according to Drinkall *et al.* (1984), the sagittal spinal canal diameter cannot be used for the management or the prognostic value of lower back pain. Furthermore, Legg and Gibbs (1984) could not find a clear link between individual anthropometric characteristics such as stature and body weight and spinal canal size. Stockdale and Finlay (1980) describe in their ultrasound based study differences in symptomatic *versus* asymptomatic individuals especially in form of a narrower sagittal spinal canal diameter at L5 in the latter group. In another large ultrasound study, Porter *et al.* (1980) found that the size of the spinal canal does not

correlate with occupation, therefore, an altered spinal canal might be more likely due to an ontogenetic rather than degenerative etiology. In general, symptomatic individuals show more often in ultrasound imaging a narrow spinal canal than their asymptomatic counterparts (Porter *et al.*, 1978a).

Furthermore, age, associated disc pathology, a trefoil-shape of the canal, degenerative vertebral bars, soft tissue alterations and instability contribute as well (Porter *et al.*, 1978a; Porter *et al.*, 1980). A strong correlation exists between vitamin D deficiency and lower back pain in areas with such endemic vitamin shortage (Al Faraj and Al Mutairi, 2003). Also Macdonald *et al.* (1984) found that smaller spinal canal dimensions are linked with higher back pain morbidity. The size of the oblique sagittal spinal canal dimension correlates with the treatment in symptomatic individuals but the size of the L5 lumbar canal does not correlate with the intra-operative findings (Porter *et al.*, 1978a). In an X-ray based study, Ramani (1976) reports differences in spinal canal / vertebral body ratios between asymptomatic and symptomatic individuals, with the latter ones having narrower spinal canals. As already mentioned above, Dommisse (1974) emphasises that the narrowest osseous spinal canal dimensions in the mid-thoracic region correlate with the region where the vascular supply for the spinal cord is the least, causing in some cases paraplegia. Eisenstein (1977) reports an uniform shape and capacity of the lumbar spinal canal, regardless of sex or inter-populational background. No significant difference, between a symptomatic and a control group, in lumbar vertebrae diameters have been reported by Larsen and Smith (1980b). On the other hand, the occurrence of the anatomical variation of the trefoil shaped lumbar spinal canal can vary between sex and inter-populational groups (Eisenstein, 1980). In general, Kikuchi *et al.* (1977)

highlighted already the fact that the lumbar osseous spinal canal shows a high variability in size and shape.

A plethora of cut-off points for pathologic spinal neural pathways has been proposed so far (Elsberg and Dyke, 1934; Larmon, 1944; Wolf *et al.*, 1956; Epstein *et al.*, 1964; Hinck *et al.*, 1966; Williams, 1975; Kikuchi *et al.*, 1977; Porter *et al.*, 1978a; Ullrich *et al.*, 1980; Kirkaldy-Willis *et al.*, 1982; Bolender *et al.*, 1985; Hasegawa *et al.*, 1995; Lee *et al.*, 1995; Inufusa *et al.*, 1996). Postacchini *et al.* (1983) doubt the value of existing cut-off points in neural canal size. According to their findings, there is also no clear correlation between the presence of a trefoil shape and the mid-sagittal dimension of the spinal canal. The depth of the lateral recess decreases caudally and seems to be linked to the shape of the neural canal and the pedicle length. Furthermore, according to them the last two lumbar levels show the biggest normal variability. The interpedicular distance is always bigger than the mid-sagittal one, making the later one, according to Postacchini *et al.* (1983), the clinically more vulnerable. They also describe the presence of at least some relationship between the mid-sagittal neural canal dimensions and interpedicular distance and vertebral body size. Additionally, Postacchini *et al.* (1983) also found abnormally sized lateral recesses in cases of normal neural canal dimensions, and the lateral recess size in an individual with ontogenetically altered neural canal dimensions may be more easily affected in pathologic situations.

The overall high prevalence of radiologically detectable cervical spinal pathologies has been showed by Pallis *et al.* (1954). Surprisingly, after the age of 50, neither the incidence nor the severity of canal or foraminal narrowing increased in his sample of patients without neurological symptoms. Beside age *per se*, they discuss other possible etiological factors such as spinal arteriosclerosis or fibrosis as well.

The concept of "spinal reserve capacity", as proposed by Weisz and Lee (1983) for the lumbar spine, allows to correlate to a certain extent the absences of morphological reserve space with the ability of coping with pathological positional situations. In the elderly and in cases of spinal canal narrowing, when the spinal reserve capacity is reduced, as proposed by Weisz and Lee (1983), clinical symptoms of lower back pain may occur. Also the lowest lumbar level seems to show the highest variability of the spinal canal reserve capacity, which may defy the correlation of measured osseous diameters and, based on this, assumed spinal cord morphometry (Weisz and Lee, 1983). How far spinal stenosis as a clinical entity is a result of lack of canal capacity or more of its neural content is still unclear (Huizinga *et al.*, 1952). Dissimilar patterns and significant differences can be found in motion of patients and healthy subjects (Dvorak *et al.*, 1993).

Flexion, extension, lateral bending and axial rotation change the relationship of the ligamentum flavum and the intervertebral disc to the spinal nerve (Vital *et al.*, 1983; Louis, 1985; Liyang *et al.*, 1989; Mayoux-Benhamou *et al.*, 1989; Nowicki *et al.*, 1996; Schmid *et al.*, 1999; Fujiwara *et al.*, 2001). The non-pathologic spine shows a range in motion from flexion through extension of approximately 70°, with the majority of it being localised in the lowermost spine (Park, 1980). The thickness of the ligamentum flavum increases bilaterally in extension (Vital *et al.*, 1983; Nowicki *et al.*, 1996; Schmid *et al.*, 1999; Chung *et al.*, 2000; Fujiwara *et al.*, 2001). Besides a described asymmetry of the right and left foramen, Mayoux-Benhamou *et al.* (1989) found a significant decrease of the intervertebral foramen size in extension, whereas the flexion position shows the opposite. Similar findings of altered size in lumbar intervertebral foramen size have been reported by Schmid *et al.* (1999). According to them, after a modelled intervertebral disc

collapse, these positional differences were much smaller. Mayoux-Benhamou *et al.* (1989) report no significant differences of intervertebral foramen sizes at various lumbar levels. For the cervical spine, Yoo *et al.* (1992) described an increase in the foramen size caudally. Yoo *et al.* (1992) also stress the fact that ipsilateral rotation increases the narrowing of the intervertebral foramen. This is particularly important, according to them, since, most cervical spine movements are combined multi-planar ones. Fujiwara *et al.* (2001), Mayoux-Benhamou *et al.* (1989), Nowicki *et al.* (1996) and Yoo *et al.* (1992) addressed in dynamic cadaver studies the alterations of the intervertebral foramen dimensions in extreme extension, flexion and rotational pose, the major positional influences on human intervertebral foramen widths. Rauschning (1987) also examined the influence of positional movements on the lumbar intervertebral foramen in a cadaver based study. Liyang *et al.* (1989) showed, in a cadaver lumbar spine study, that in flexion not only the capacity of the spinal canal increased but also the length of the spinal canal and the posterior height of the intervertebral discs. Veleanu (1972; 1975) reports the impact of rotational movements on the cervical spine and how the transverse process helps to block non-physiological positions. Whereas extreme form of flexion mainly causes high tensions within the posterior ligaments, extreme lordosis has a high impact on the apophyseal joints (Adams *et al.*, 1994). Lumbar lordosis was not found to be linked with lower back pain (Murrie *et al.*, 2003). Flexion of cervical (Yoo *et al.*, 1992) or lumbar spine (Panjabi *et al.*, 1983; Liyang *et al.*, 1989; Nowicki *et al.*, 1996; Schmid *et al.*, 1999; Fujiwara *et al.*, 2001) increases the dimension of the neural pathways, especially of the intervertebral foramina, whereas extension decreases it drastically. Nowicki *et al.* (1996) widely addressed the effect of body positions such as flexion, extension, lateral bending and axial rotation on the lumbar intervertebral foramen

dimensions, whereas Veleanu (1972; 1975) focused on the particular situation of movements in the cervical spine. Fujiwara *et al.* (2001) did a similar study on the impact of various body positions on the intervertebral foramen size in motion segments of the lumbar cadaver spine. In case of degenerative alterations, Panjabi *et al.* (1983) found a higher decrease in size in physiologic-dynamic situations, such as rotational movements, for intervertebral width than height.

The bulging of the intervertebral disc is, according to Reuber cited by Panjabi *et al.* (1983), in case of degenerative lumbar spine approximately 2 mm. An artificial collapse of the intervertebral disc, which anatomically influences the neural pathways less than a degenerative disc with subsequent fattening and protrusion, decreased the relative changes in relation to the two extreme positions (Mayoux-Benhamou *et al.*, 1989).

Computer assisted simulation of narrowing of intervertebral disc space to determine the relationship between intervertebral disc height, which is greatest anteriorly, and the size of the intervertebral foramina, with a 1 mm narrowing leads to a reduction of 20% to 30% of the foraminal area (Lu *et al.*, 2000). In a similar study by Cinotti *et al.* (2002), the artificial narrowing of the disc space caused mainly a decrease in intervertebral foramen height, rather than foramen width. The latter one was more linked to the sagittal diameter of the spinal canal or pedicle length.

The use of a chronic compression model in rats allowed Iwamoto *et al.* (1995) to explore the sequence of pathologic alterations in lower lumbar spinal compression. Surprisingly, at the very beginning of such a process, the epidural blood vessels are damaged and only later in the long-lasting process the nerve roots are injured.

Cross-sectional areas of the non-pathologic spinal cord in cadavers have been published earlier (Lassek and Rasmussen, 1938; Elliott, 1945; Kameyama *et al.*, 1992).

Scoles *et al.* (1988) provide gold-standard data of the non-pathologic spinal canal dimensions in the macerated thoraco-lumbar spine. Bolender *et al.* (1985) provided radiological values of cross-sectional areas of the dural sac and spinal canal diameters in symptomatic patients. Inufusa *et al.* (1996) report a significant correlation between the mid-sagittal diameter of the spinal canal and its cross-sectional area on the lumbar level. Inufusa *et al.* (1996) report as normal value for the lumbar spinal canal an overall cross-sectional area of 200 mm^2. The measuring the mid-sagittal diameter, as done in their study, allows estimating overall canal size. These sizes show for the neural tissue no significant correlation with body weight but with body height, and a remarkable inter-individual variation. The relative cervical cross-sectional area, according to Kameyama *et al.* (1992), is alike within individuals. According to Gepstein *et al.* (1991) the sagittal diameter of the spinal canal is the only parameter of a series of osseous vertebral dimensions, which correlates with the cross-sectional area of the spinal canal. Eisenstein (1977) recommends focusing on the absolute values in sagittal canal dimensions, which are more crucial than the transverse diameter or any ratios with the vertebral bodies. This view of mainly the sagittal diameter of the spinal canal being the clinically critical measurement, is also supported, at least for the cervical spine, by Wolf *et al.* (1956) or for the lumbar spine by Kikuchi *et al.* (1977).

A clear relationship between intervertebral foramen height and sagittal diameter of the spinal canal was reported by Epstein *et al.* (1964), which they declare to be a crucial factor, together with a tendency of narrowing in the lateral recess, in the occurrence of clinically relevant spinal diseases. In an earlier report, Epstein *et al.* (1962) discuss the importance of decreased lateral spinal canal recess size in the occurrence of clinical lower back symptoms. Such a variation in lateral recess size can be found, according to them in

approximately 10-15% of all individuals. The particular shape of the lateral recess has also been addressed widely by Kikuchi *et al.* (1977). Eisenstein (1977) summarizes in his lumbar spine study that the osseous narrowing of the spinal canal, as the only reason for spinal stenosis, may not be correct. Spinal stenosis will affect more the intervertebral foramen than the main vertebral canal. In another study by Eisenstein (1980), he rules out facet osteophytes or trefoil configuration of the lumbar spinal canal as main etiologies for nerve root compression.

The clinically crucial and unique patho-anatomical features of the intervertebral foramen have already been addressed by Magnuson (1944) and Rauschning (1987). Surprisingly, Magnuson (1944) found the root ganglion in fresh cadavers to fill out the vast majority of the foramen and, furthermore, he describes a high variability of the anatomy of the intervertebral foramen and its content. Hasegawa *et al.* (1995) found, in their cadaver study of the lumbar spine, a significant correlation between posterior intervertebral disc height and foramen height. Furthermore, they found a correlation between foraminal cross-sectional area and the nerve roots size. The ratio of these two measurements was higher, according to Hasegawa *et al.* (1995), in individuals with a possible nerve root compression. Additionally, in the possibly affected subgroup the posterior disc height as well as the foraminal height was generally smaller. As Putti (1927) already stated, there seems to be a mismatch between intervertebral foramen space and spinal nerve size particularly in the two lowest lumbar segments. Ebraheim *et al.* (1996) provided cadaver and macerated cervical intervertebral foramen dimensions acquired in neutral position, which can be used as reference data. In a cadaver study, Hoyland *et al.* (1989) suggest that mechanical occlusion of the intervertebral foramen venous plexus could lead via ischemia to periradicular fibrosis and, therefore, to clinical

symptoms. They report a positive correlation between the sizes of the venous plexus, which would be increased in cases of mechanically caused stasis, and the amount of neural fibrosis to be found in the intervertebral foramen. On the other hand, Rauschning (1987) found in cases of present disc bulging decreased diameters of the adjoining venous structures. In a recent skeletal series, Amonoo-Kuofi (1985) found a high degree of variation of the intervertebral foramen width, a decrease in size caudally in the lumbar region and a connection of its size to the sagittal diameter of the vertebral body. Amonoo-Kuofi (1985) explains the fact that L1 shows the largest sagittal neural canal diameter of all lumbar levels with various influences. The change of the thoracic kyphosis towards the lumbar lordosis, the lower end of the main spinal cord at this level and the fact that this seems to be a transition point from the more rigid thoracic spine to the movable lumbar section could all be possible reasons. In general, the morphometric pattern of the lumbar spinal canal and the lumbar intervertebral foramen are more related to alterations of laminae morphometry than with pedicle size (Amonoo-Kuofi, 1985). This view is also expressed by Eisenstein (1977), who traces mid-sagittal stenosis of the lumbar spinal column back to be a result of shortening of the lamina rather than of the pedicles.

A novel approach was selected by Porter *et al.* (1987) in relating clinically relevant narrowed spinal canal conditions and possible health and educational etiologies. The sub-sample of adult patients with a narrow sagittal spinal canal *versus* a sub-sample of individuals with a wide sagittal spinal canal showed more episodes of lower back pain, infections and trauma related attendances at their general practitioner but less episodes of allergies per year. No significant correlation was found with dermatological, gynaecological or psychological episodes and spinal canal size (Porter *et al.*, 1987). Additionally, children showed a correlation between wider sagittal spinal canal size and

better school test scoring (Porter *et al.*, 1987). Furthermore, workers with smaller spinal canal dimensions show in general a higher lower back morbidity (Macdonald *et al.*, 1984).

Historical perspectives of spinal disorders and morphometry

A historic perspective on the spinal morphology is still not widely used. In a archaeologic pilot study exploring the possible influences of individual hardship during growth on juvenile spinal canal dimension, Porter and Pavitt (1987) describe several significant links between individual skeletal or dental stress markers such as Harris lines, cribra orbitalia, porotic hyperostosis or dental hypoplasia. Noteworthy, they found a positive correlation between the decrease of mid-sagittal spinal canal size, which is the most important clinical diameter of spinal neural pathways, and the occurrence of Harris lines on most lumbar levels (Porter and Pavitt, 1987). Porter and Pavitt (1987) postulate that unknown factors acting on the foetal development of the individual spinal canal may also result in a susceptible immune system. Therefore, the latter could explain the link with the occurrence of Harris lines, since Harris lines are in general to be more frequently found in cases of severe acute infection or poor diet. The secular change of neural spinal pathways in a cultural transition period from a hunter-gatherer to a settled agricultural society in North America was examined by Clark *et al.* (1985). They found a slightly smaller sagittal spinal canal dimension in the thoracic and lumbar spine in the agricultural society, even after controlling for sex and age. For the transverse diameters, only females had smaller dimensions, whereas males had higher values than their hunter-gatherer counterparts. The agricultural males also had larger lumbar vertebral body heights; which was less expressed in the thoracic spine and with an opposite trend for females (Clark *et*

al., 1985). Clark *et al.* (1985) state that the lumbar sagittal spinal canal dimension is an excellent indicator for disrupted growth in individual's early life. This dimension is not correlated with tibial length, whereas transverse diameters are. Both, tibial length and vertebral body height did, according to the results by Clark *et al.* (1985) not change during a cultural shift. Since the thoracic spine completes more of its growth in the prenatal stage than the lumbar spine, it is not surprising that the first one shows stronger correlations between main spinal canal dimensions and vertebral body height (Clark *et al.*, 1985). Clark *et al.* (1985) describe more correlations of various osteometric spinal assessments. Sagittal and transverse spinal canal diameters are correlated as high as transverse spinal canal diameter and age groups. Furthermore, transverse spinal canal diameter is correlated with sex, unlike the sagittal diameter. Posterior vertebral body height is correlated with sex and cultural transition. Finally, anterior vertebral body height is also correlated with cultural change and with posterior vertebral body height. Clark *et al.* (1985) also found that intervertebral foramen width is only correlated with sagittal diameters of the spinal canal but not with the transverse diameter of the spinal canal or with vertebral body height. These correlations seem not to be clouded by variables such as sex, age or culture (Clark *et al.*, 1985). The shift from a protein-rich hunter-gatherer society to a protein-poorer agricultural life style, as examined by Clark *et al.* (1985), results in smaller spinal canals. This is more strongly expressed in the sagittal dimension, which is more vulnerable to influences in the pre-and neonatal growth period and more visible in the lumbar spine (Clark *et al.*, 1985).

In an osteometric studies including two Early Medieval samples from present Poland, Piontek (1973), found a strong correlation for all vertebral levels between sagittal and transverse diameters, but no such significant relationship exists for the majority of all

vertebral levels between these two diameters measurements and the vertebral body height. Piontek (1973) describes, with just a few exceptions, a correlation between the transverse vertebral body diameter and the transverse spinal canal diameter. This seems, according to him, not to be true for the sagittal dimensions of these two structures. Another study briefly focusing on historic spinal morphometry is the one by Tatarek (2001).

From a historic perspective, changes in the prevalence of degenerative spinal diseases have been linked to possible alterations in cultural and, therefore, mechanical loads (Larsen, 1980; Larsen, 1981; Larsen, 1982; Bridges, 1991). Larsen (1980; 1981; 1982) mentions a significant decrease of cervical and lumbar degenerative joint diseases, with a reduction of up to 27% of its prevalence, from a pre-agricultural hunter-gatherer society to a settled corn dependent agricultural community, both located in the same American costal area. He explained this as being related to a decrease in mechanical stress due to the change in life-style (Larsen, 1980; Larsen, 1982).

The osteometric definitions of spinal landmarks allow comparison of data with various geographic and historic backgrounds (Aeby, 1879; Anderson, 1883; Rosenberg, 1899; Wetzel, 1910; Hasebe, 1913; Thomson, 1913; Cyriax, 1920; Stefko, 1926; Jacobi, 1927; Martin, 1928; Frey, 1929; Matiegka, 1938; Wood-Jones, 1938; Lanier, 1939; Huizinga *et al.*, 1952; Francis, 1955; Davis, 1961; Schultz, 1961; Stewart, 1962; Epstein *et al.*, 1964; Kaliszewska, 1966; Hurxthal, 1968; Piontek and Budzynska, 1972; Piontek and Zaborowski, 1973; Dommisse, 1974; Dommisse, 1975; Heim, 1976; Cwirko-Godycki and Swedborg, 1977; Eisenstein, 1977; Kikuchi *et al.*, 1977; Riegerova, 1979; Tibbetts, 1981; Postacchini *et al.*, 1983; Nissan and Gilad, 1984; Amonoo-Kuofi, 1985; Trinkaus, 1985; Cotterill *et al.*, 1986; Gilad and Nissan, 1986; Nakashima, 1986; Nissan and Gilad, 1986; Berry *et al.*, 1987; Porter and Pavitt, 1987; Minne *et al.*, 1988; Scoles *et*

al., 1988; Gepstein *et al.*, 1991; Sanders, 1991; Jankauskas, 1994; Lee *et al.*, 1995; Tominaga *et al.*, 1995; Xu *et al.*, 1995; Sanders, 1998; Tatarek, 2001).

Nevertheless, as Katz *et al.* (1975) stated at least for the cervical spine, there is not much data available e.g., on vertebral body size. Scoles *et al.* (1988) highlight this fact in terms of the absence of knowledge on the thoraco-lumbar spinal morphometry, despite its crucial need of it e.g., in orthopaedic surgery.

This lack of morphometric information is striking especially if one is aware of the importance, such as in modern clinical medicine, of human spinal disorders linked with morphologic mal-adaptations. Furthermore, this lack of knowledge on spinal short-term evolution is surprising in particular for the macerated intervertebral foramen and neural canal dimensions. At least for the cervical intervertebral foramen dimensions one can rely on data published by Ebraheim *et al.* (1996). Nevertheless, the well-established standard measurement schemes by Hasebe (1913) and Martin (1928) provided definitions for the measurement of the spinal canal diameters only.

Surprisingly, no study including historic specimens paid full attention to possible secular trends in spinal neural pathways dimensions. The assessment of the intervertebral foramen is crucial as its alterations play a significant role in the pathophysiology of radiculopathy or spinal stenosis, main etiologies of back pain, which, cause enormous costs in industrialized countries health care (Maniadakis and Gray, 2000). No study exploring a possible secular alteration of the intervertebral foramen in post-industrialization societies exists. Since the inverted teardrop-like shape of the superior and inferior soft tissue parts of the intervertebral foramen space (Swanberg, 1915; Panjabi *et al.*, 1983; Vital *et al.*, 1983; Rauschning, 1987; Inufusa *et al.*, 1996) is different from its osseous outline, earlier proposed clinical measurements (Ciric *et al.*, 1980; Mayoux-

Benhamou *et al.*, 1989; Humphreys *et al.*, 1998; Chung *et al.*, 2000) cannot be easily reproduced on dry bone specimens. Hitherto, the assessment of the macerated intervertebral foramen was done for just one or two of the three main spinal regions (Clark *et al.*, 1985; Ebraheim *et al.*, 1996; Boszczyk *et al.*, 2001) or explored in a prehistoric sample (950-1300 A.D.) only (Clark *et al.*, 1985).

Microevolutionary trends of specific spinal pathologies such as spina bifida occulta (Henneberg and Henneberg, 1999), ossification of the posterior longitudinal ligament (Hukuda *et al.*, 2000), spondyloarthropathy (Rothschild and Rothschild, 1996), vertebral body size (Clark *et al.*, 1985; Jankauskas, 1994) or neural canal dimensions (Piontek and Budzynska, 1972; Clark *et al.*, 1985; Tatarek, 2001) have been published. On the other hand, Jankauskas (1992) found no clear secular trend in the occurrence of spinal pathologies such as osteophytes or Schmorl's nodes.

Another important spinal neural pathway – the size of the neural canal - has been investigated among others by Tatarek (2001). Upon examination of lumbar region only, she found, significant variation in relation to sex, individual age, geographic origin and historic background of the sample. Specimens from the 19th century were analysed for their lumbar spinal canal size by Huizinga *et al.* (1952), but without a secular perspective.

Correlations of the main spinal diameters with vertebral body diameters and long bone measurements have been shown in an archaeological sample by Hibbert *et al.* (1981b). According to their study, the interpedicular distance and the spinal canal area showed such correlations, whereas the mid-sagittal diameter of the vertebral canal did not. A possible relation between juvenile neural canal size and the occurrence of individual stress markers, such as dental hypoplasia or Harris lines has been investigated by Porter and Pavitt (1987) on two historic samples. They found e.g., a correlation

between the dental hypoplasia in an individual and a small lumbar interpedicular distance or between the presence of a small sagittal diameter of the spinal canal and the prevalence of Harris line.

The non-human spine

Various functional and morphological aspects of the non-human spinal column have already been addressed (Keith, 1902; Wetzel, 1910; Nathan *et al.*, 1964; Mehler, 1969; Farfan, 1978; Cotterill *et al.*, 1986; Fox and Wilczynski, 1986; Pun *et al.*, 1987; Shapiro, 1993; MacLarnon, 1995; Shapiro, 1995; Tominaga *et al.*, 1995; MacLarnon, 1996a; MacLarnon, 1996b; Sanders, 1998; Boszczyk *et al.*, 2001; Kandziora *et al.*, 2001; Argot, 2003). Animal spines have been used as models for the human spine for various reasons. Both, the cervical spine of sheep (Kandziora *et al.*, 2001) as well as the one of the baboons, at least as highlighted by Tominaga *et al.* (1995) show to a certain degree similarities to the human spinal anatomy.

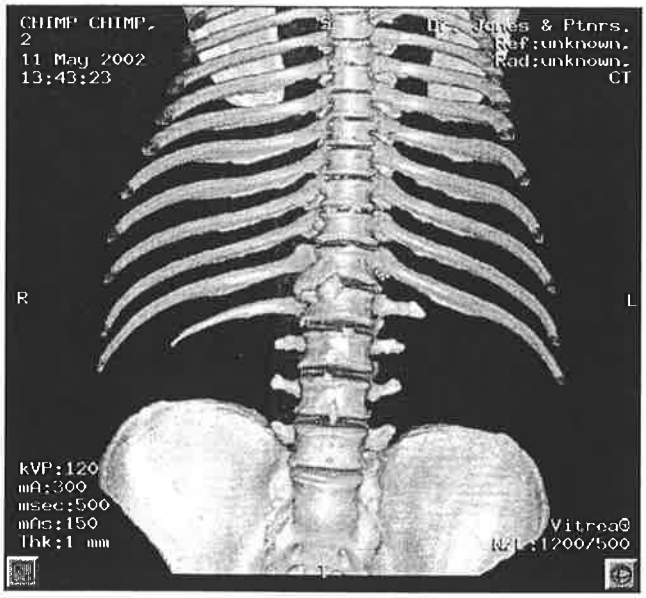
The increase in spinal cord size during primate evolution is explained by MacLarnon (1996a) most likely due to increased complexity in locomotion. Both, *Homo sapiens* and *Pan troglodytes* show a sudden end of the spinal cord, most likely due to the absence of any tail. The expansion of the corticospinal tract, only to be found in mammals and important for fast and smooth activities (Towe, 1973), and of the dorsal columns, consisting of afferent sensory nerves, within the spinal cord, could be the reasons for the increase in cervical and thoracic spinal cord dimensions during primate evolution (MacLarnon, 1996a). The human lumbar spinal canal shows, according to MacLarnon (1995), even more particularities, such as the lack of any decrease in diameter towards its caudal end. MacLarnon (1995) explains this as being a result of intrinsic and / or extrinsic

influences, such as bipedialism, acting on the vertebral canal. The osseous human spinal canal, therefore, does not reflect its neural content as it does in other primates. This is only true for the lumbar segment, since for the more cranial parts such a correlation apparently does exist (MacLarnon, 1995).

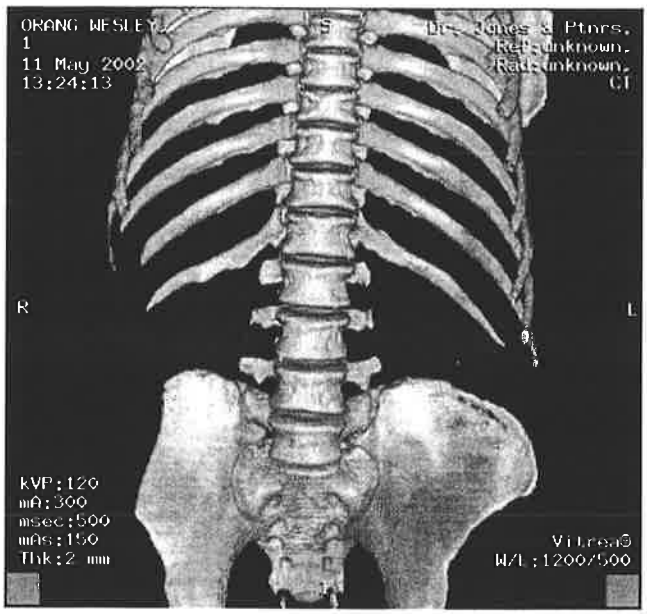
Surprisingly, in comparison with other primates humans tend to have large and wide pedicles in relation to their pedicle length and body size (Shapiro, 1993). At least this distinctive human pedicle morphology may be resulting from the unique pattern of locomotion (Shapiro, 1993). Furthermore, human lumbar pedicle morphology may echo bending forces and may by influenced by the presence of the ilio-lumbar ligament (Davis, 1961; Shapiro, 1993).

The particular spinal anatomy with its bulky lower back muscles, the functional lordosis and a more dorsal displacement of the posterior spinal ligaments, makes humans able to handle much higher weight bearing than their primate relatives (Farfan, 1978).

As a side issue of this work, which will not be further addressed, CT scans of some selected ape cadavers have been performed to illustrate the *in vivo* spinal morphology, and in particular the relation between vertebral body height and intervertebral disc dimensions in the lumbar spin; see also Figure 2.

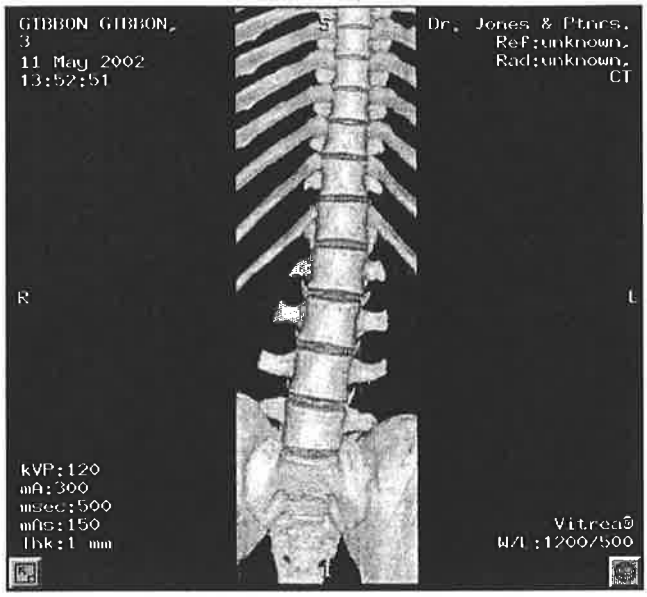


a) Chimpanzee (*Pan troglodytes)*



b) Orangutan (*Pongo pygmaeus*)

Figure 2: CT based 3-D-surface reconstructions of thoracic and lumbar spines of selected ape cadavers



c) Gibbon (*Hylobates, species unknown*)

Figure 2 (cont.): CT based 3-D-surface reconstructions of thoracic and lumbar spines of selected ape cadavers

Earlier reports (Keith, 1902; Schultz, 1961) addressed the variation in the non-human spine in comparison with its situation in humans. Bohart (1929) already mentioned the fact, that sacralisation of the lower lumbar spine is not only very frequent in humans, but even more often to be found in some species of monkeys. The primate spinal cord does not differ from the one in other mammals with regard to its size / body weight ratio, also there is just a small variation in relative cord length in primates (MacLarnon, 1996b). Primate spinal cord weight and length are strongly correlated with body weight (MacLarnon, 1996b). Shapiro (1993) examined the features of the vertebral body surface areas and pedicle dimensions among primates including an *Australopithecus africanus* individual and anatomically modern human samples. The influence of unique human posture and locomotion was in general found to be weaker than expected (Shapiro, 1993). To summarize, Farfan (1978) concludes that the human spine is from an evolutionary perspective a well adapted structure.

Major evolution of the human spine and its physiological adaptations

The human vertebral column has evolved from the ones of other primates by adaptations possibly linked with changes in life-style and environmental habitat. Boszczyk *et al.* (2001) highlights the fact that humans, in comparison to their closest living relative, the chimpanzee, show a functional adaptation to the higher axial loading, mostly by an increase in the transverse rather than the sagittal vertebral body diameter. This allows humans to have a relatively large surface area, especially in the lumbar spine. Mehler (1969) mentions not only the increase of the spino-thalamic tract during mammal evolution, but also as a cut-off between the neuronal tract of humans and chimpanzee

versus other primate and non-primate spines, the absence of the spino-olivary connections in the formers, with this fact possibly being a reflection of bipedal locomotion.

Another striking evidence of unique human neuronal evolution has been reported as the loss of a sialic acid (Varki, 2001). Other possible examples of biochemical evolution in humans (Rühli and Henneberg, 2001; Rühli and Henneberg, 2002) will be addressed later in this work.

The particularities of the human lumbar spine in relation to it closest relatives have been highlighted by Farfan (1978), by emphasizing the great functional variability due to e.g., greater thickness of lumbar discs. Schultz (1961) pointed out, that the human spine shows, due to the particular posture and its related mechanical implications, very broad lumbar vertebrae. The reduction of the nuchal musculature, according to Schultz (1961), results in exceptionally short cervical spinous processes in humans.

The spinal morphology is reflective of the amount or direction of physical forces acting on vertebrae (Davis, 1961; Putz, 1981; Louis, 1985). In contrast to terrestrial quadrupedal animals, the human spine is exposed to the demands of bending. The impact of locomotion patterns such as bipedialism, posture influences and other functional aspects e.g., loading / forces in lifting, of the vertebral column and its linked muscles have been outlined earlier (Davis, 1961; Nathan *et al.*, 1964; Putz, 1981; Yettram and Jackman, 1982; Louis, 1985; Pun *et al.*, 1987; Sanders, 1991; Putz and Müller-Gerbl, 1996; Sanders, 1998; Boszczyk *et al.*, 2001). It is well known that bipedialism directly influences the arrangement of central nervous system structures such as e.g., the position of the spinal cord in relation to the brain and thus the placement of the foramen magnum (Schaefer, 1999). The particular interaction of physiological and pathological mechanics and spinal anatomy has also been discussed in earlier reports (White and Hirsch, 1971;

Panjabi *et al.*, 1976; Farfan, 1978; Nachemson *et al.*, 1979; Yettram and Jackman, 1982; Panjabi *et al.*, 1983; Louis, 1985; Silva *et al.*, 1997; Sanders, 1998).

The early hominids, the *Australopithecines,* show different spinal morphology than modern *Homo sapiens* (Cook *et al.*, 1983; Sanders, 1998), with some functional implications such as proposed greater massiveness of their back musculature. Osteoarthritic changes, as seen e.g., in the skeleton of the La Chapelle-aux-Saints 1 remains of *Homo sapiens neandertalensis* (Trinkaus, 1985), influence the morphologic characteristics of the human vertebral column. Another example of a frequent pathology interfering with normal spinal architecture is juvenile kyphosis, so called Morbus Scheuermann, which e.g., was supposed to be present in the Al-288 *Australopithecus afarensis* skeleton (Cook *et al.*, 1983). Individual STS 14, an *Australopithecus africanus*, showed distinctive morphological features compared to modern humans by having small vertebral surface areas and relatively short pedicles at L6, both suggesting a possibly unique locomotive pattern or being simply an allometric trait related to small size (Shapiro, 1993). Sanders (1991) studied the cross-sectional areas of the neural canal for each level in the lumbar spine. Among hominoids, lumbar canal decreases in size relative to centrum areas with increasing body weight. Modern humans generally possess much larger neural canal areas relative to body size than their ancestors. The lumbar vertebrae of *Australopithecines* show smaller centra than predicted for their estimated body sizes and relatively wide neural arches and canals (Sanders, 1991). The intervertebral foramina of the STS 14 individual are supposed to be relatively large in comparison with modern humans, unlike its relatively short pedicles (Shapiro, 1993). The spinal nerve size of STS 14 may have been increased or, more likely, the spinal nerves may had occupied relatively less space of the intervertebral foramen as in anatomically modern humans,

making a symptomatic nerve injury less likely in STS 14 (Shapiro, 1993). The Early Upper Paleolithic individuals from Predmosti, which are of the Cro-Magnon type, show in comparison to modern samples relatively small neural pathways (Matiegka, 1938). Stewart (1962) found no evidence for an anatomical essentially different cervical spine in Neandertals in comparison to modern humans and describes the long spinous process at C5 as one characteristics of the Neandertal spine. Apparently, the lower cervical spinous process became less robust. Additionally, European Neandertals show relatively shorter upper and lower limbs, as pointed out by their brachial and crural indices (Trinkaus, 1981; Ruff, 1994; Holliday, 1996; Holliday, 1997; Holliday, 1999). It is also still debated how the scapula morphology of the Neandertals changed towards modern humans (Churchill, 1996). Trinkaus (1985) and Heim (1976) emphasize the high robusticity of the Neandertal spine in comparison to the one of anatomically modern humans, but both also stress that conclusions drawn shortly after the discovery of these skeletons about its special morphology are not correct. Heim (1976) mentions, among other particularities, the big cervical neural canal of the La Ferrassie 1 Neandertals individual as well as its robust cervical neural arch.

Some altered spinal features are expressed in modern humans e.g., as variation of the number of vertebrae, mostly thoracic and lumbar, increased spinous process or neural canal size, changed intervertebral disc height, changed numbers of segmental nerves in comparison with total number of vertebrae, variation of the foramen of the transverse process, or different proportions of the major spine regions (Keith, 1902; Horwitz, 1939; Francis, 1955; Gill and White, 1955; Bornstein and Peterson, 1966; MacGibbon and Farfan, 1979; Cotterill *et al.*, 1986).

The resulting anatomical arrangement of the human spine can generally be explained by its mechanical needs (Davis, 1961; Farfan, 1978; Louis, 1985; Putz and Müller-Gerbl, 1996). Silva *et al.* (1997) explored specifically the load distribution between the centrum and shell of the lower back vertebrae, with the first one apparently bearing the vast majority of the body weight *in vivo*. Unfortunately, they did limit their study to forces acting on the vertebral body only and did not include the neural arch (Silva *et al.*, 1997). In another biomechanical study, Nachemson *et al.* (1979) reported on the influence of age, sex and degenerative changes on the properties of lumbar motion segments. They found no clear correlation between any of these factors and altered mechanical performance. As already outlined above, the main parts of the spinal column serve different purposes. Therefore, they may react independently and differently to environmental stimuli.

One example of spinal alterations is the evolution of the human spinal lordosis; which develops at least partially during early ontogeny (Horner, 1854; Aeby, 1879). The human spinal lordosis is usually considered to be a result of bipedialism (Martin and Saller, 1957; Farfan, 1978), since it is not present in the monkeys, despite the anthropoid ape being able to sit in an upright position (Pun *et al.*, 1987), or in the bovine spine (Cotterill *et al.*, 1986). The pedicles and the other posterior elements of the vertebral column seem to play a crucial role in relation to human lordosis and bipedialism as pointed out by Davis (1961). The lumbar vertebral column of *Australopithecus africanus* exhibits a lordosis similar to the one of *Homo sapiens* (Martelli and Schmid, 2000). The lordosis of the lumbar spine, which is typical for humans, is an acquired ontogenetic character (Aeby, 1879; Martin and Saller, 1957). Males have usually a more prominent kyphosis of the thoracic (Jankauskas, 1994) and a developed curvature of the lumbar

spine (Hasebe, 1913). Anatomical alterations of the same structure but on dissimilar levels can be a result of different etiologies. Cervical lordosis, for example, is apparently an exclusive effect of intervertebral discs, whereas the lumbar lordosis is a result of both, the arrangement of the vertebral bodies and of the intervertebral discs (Jankauskas, 1994).

Besides obvious osseous adaptations, the non-osseous parts of the human spine such as the ligamentous elements are expressing evolutionary adjustments as well (Farfan, 1978). The ligamentous apparatus of the vertebral column, which includes beside the major anterior and posterior intervertebral ligaments the annulus fibrosus of the intervertebral disc, is of particular evolutionary relevance (Farfan, 1978).

The mechanical load bearing function of the human spine, as it is evolved into its current physiological form, is vital. The main function of the human intervertebral discs is to distribute equally any mechanical loading regardless of the vertebral position. In addition, the deep back muscles as well as various ligaments support this function. The anatomical adaptation of the spine in general can be seen as the best solution of very competitive needs, this is stability and mobility (Darwin, 1859; Davis, 1961; Veleanu, 1972; Veleanu, 1975; Putz, 1981; Louis, 1985; Putz and Müller-Gerbl, 1996; Boszczyk *et al.*, 2001). The still ongoing evolution of the human vertebral column can also be investigated by exploring the frequency and extent of anatomical variations and by the occurrence and type of pathologic mal-adaptations.

Anatomical variations of the spine

Numerous variations in the occurrence, the arrangement and the function of soft tissue body parts such as muscles, vessels or visceral organs exist. Anatomical variations in the human vertebral column are rather frequent. Many studies have been conducted to

explore the form and intensity of expression of spinal variations (Rosenberg, 1899; Dwight, 1901; Keith, 1902; Cyriax, 1920; Willis, 1923; Willis, 1924; Putti, 1927; Martin, 1928; Bohart, 1929; Cushway and Maier, 1929; Frey, 1929; Willis, 1929; Giles, 1931; Philipp, 1932; Stewart, 1932; Junghanns, 1933; Horwitz, 1939; Lanier, 1939; Larmon, 1944; Magnuson, 1944; Allbrook, 1955; Francis, 1955; Gill and White, 1955; Schultz, 1961; Epstein *et al.*, 1962; Burrows, 1963; Epstein *et al.*, 1964; Post, 1966; Salamon *et al.*, 1966; Veleanu, 1975; Arnoldi *et al.*, 1976; Eisenstein, 1977; MacGibbon and Farfan, 1979; Riegerova, 1979; Eisenstein, 1980; Susa and Varga, 1981; Tibbetts, 1981; Hasue *et al.*, 1983; Kikuchi *et al.*, 1984; Larsen, 1985; Parke *et al.*, 1994; Hoshovski, 1996; Tribus and Belanger, 2001). Willis (1929) differentiates between phylogenetic, (e.g., partial sacralisation of the last lumbar vertebra), developmental (e.g., defective spinous process) and acquired spinal variations (e.g., trauma related conditions).

The various patterns of variability of the human vertebral column can be shown among others by the variation in the number of vertebrae, the configuration of processes of the neural canal, the disposition and asymmetry of zygoapophyseal articular facets, the sacralisation and lumbalisation of the sacro-lumbar junction, the variation of the transverse foramen, the extent of vertebral fusions, the vertebral body, pedicle, spinal canal, spinal nerve or dural sac morphology, the variations of the nerve root sizes and the occurrence of additional ribs (Rosenberg, 1899; Dwight, 1901; Keith, 1902; Hasebe, 1913; Cyriax, 1920; Willis, 1923; Willis, 1924; Putti, 1927; Martin, 1928; Bohart, 1929; Cushway and Maier, 1929; Frey, 1929; Willis, 1929; Giles, 1931; Blumensaat and Clasing, 1932; Philipp, 1932; Stewart, 1932; Horwitz, 1939; Lanier, 1939; Allbrook, 1955; Francis, 1955; Gill and White, 1955; Schultz, 1961; Epstein *et al.*, 1962; Burrows, 1963; Bornstein and Peterson, 1966; Salamon *et al.*, 1966; Veleanu, 1975; Saillant, 1976;

Kikuchi *et al.*, 1977; MacGibbon and Farfan, 1979; Riegerova, 1979; Susa and Varga, 1981; Tibbetts, 1981; Hasue *et al.*, 1983; Postacchini *et al.*, 1983; Kikuchi *et al.*, 1984; Larsen, 1985; Hoshovski, 1996).

Anatomical variations can be extremely common even in asymptomatic individuals. Cushway and Maier (1929) found in an X-ray sample of 931 healthy men a total of 414 cases showing any osseous spinal variations. A similar percentage of approximately 45% of symptomless individuals expressing some sort of spinal variation was reported by Bohart (1929). Giles (1931) reports in an X-ray based study a prevalence of approximately 14% of vertebral anomalies of any form. This includes alterations of vertebral segmentation, hemivertebra, spina bifida, or the occurrence of cervical or lumbar ribs. A high frequency of numerical vertebral variations of approximately 15% was reported by Allbrook (1955) for a modern East African sample, whereas Bornstein and Peterson (1966) detected an overall variance of 11%, Stewart (1932) one of 12%, Tibbetts (1981) for males a total of 8% and one of 10% for females, Willis (1923) for the thoraco-lumbar spine of Whites one of approximately 5%, Blumensaat and Clasing (1932) in a clinical sample a total of 5%, Martin and Saller (1957) a total of 8% and Keith (1902) mentions the same percentage. Schultz (1961) and Frey (1929), both found a total of 31% and 32%, respectively, of any vertebral numerical variation. Dommisse (1974) describes in a sample of six cadavers one with an additional lumbar vertebra. MacGibbon and Farfan (1979) found in their large sample a total of 8% with transitional vertebra, whereas in another osteometric study, briefly mentioned in a more clinically orientated report by Gill and White (1955), 11% of skeletons show transitional vertebrae. Philipp (1932) reports more than 25% of a sample of pelvis specimens to have some sort of sacral anomalies. Epstein *et al.* (1962) estimate 10% - 15% of all individuals showing a

decreased size in the lumbar spinal canal recess size. Cyriax (1920) describes in his sample of cadaveric and macerated spines a high degree of variation especially in the vertebral size ratios. Also a high number of uni- / or bilateral alterations in numbers of vertebrae has been reported earlier by Horwitz (1939). Furthermore, he found a link in the occurrence of vertebral segmentation alterations and anatomical variations of the lumbo-sacral nerve plexus.

By addressing the blood supply of the spinal cord, Dommisse (1974), emphasizes the fact that the vascular supply shows a striking anatomical variability. Parke *et al.* (1994) describe a higher variability of the arterial supply for the three lowest lumbar intervertebral foramina than show the more cranial or caudal ones. On the other hand, Tribus and Belanger (2001) did not find a variation in the occurrence but only in the localization of the median sagittal artery. Larsen (1985) investigated not only the expression but also the variability in the posterior vertebral body anatomy by focusing e.g., on the foraminae caused by the basivertebral veins and the scalloping of the lumbar vertebrae.

A high variation in spinal nerve and intervertebral foramen arrangement was described by Magnuson (1944) based on a sample of ten fresh cadavers. Similar reports are provided by Hasue *et al.* (1983) and Kikuchi *et al.* (1984) stating that congenital variations of the nerve root, such as branching or root merges, are quite common, with a prevalence of approximately 9%. Vanderlinden (1984) describes a few clinical cases with a variant location of the dorsal root ganglion, in the proximal instead of lateral part of the intervertebral foramen, linked to sciatic pain. Francis (1955) describes a high degree of variation of the foramen of the transverse process. Horwitz (1939) mentions the variation of the lumbo-sacral and posterior sacral nerve plexus and its relation to the alteration in

number of vertebrae. Furthermore, Dunn (1912) reports a high variability for the size of cervical nerve roots in albino rats.

The trefoil shaped lumbar spinal canal, another frequent spinal morphology variant, is addressed by Eisenstein (1977; 1980) as being just an anatomical developmental modification, which is most frequent at L5 and more often to be found in females and in certain inter-populational group, and which is not primarily linked with local nerve entrapment and its subsequent symptoms. It is present in approximately 15% of all individuals at L5 (Eisenstein, 1977; Eisenstein, 1980). Postacchini *et al.* (1983) describe this particular shape in 16% of an Italian sample and in 12% of an Indian sample, but they do not describe a correlation between the trefoil shape and the mid-sagittal neural canal dimension. Furthermore, Kikuchi *et al.* (1977) stress the fact that the osseous spinal canal shows a wide variation in size and shape. The variation of the spinal dural sac has been shown by Salamon *et al.* (1966), who fund its termination at S1 / S2 in 87% of their sample only, with its ending in other cases even further caudal.

Additionally, in forensic situations the variability of the human spinal morphology in individuals has been used for identification purposes (Riepert *et al.*, 1995).

Summarizing, it is difficult to define a clear division in the human spine between a pathologic finding and an anatomical variation (Niedner, 1932; Allbrook, 1955). Bohart (1929) did not find any correlation between the presence of any spinal variation and the likelihood of work-related back injuries. Even anatomical variations itself can be tricky to be identified, especially on X-rays (Cushway and Maier, 1929). While Giles (1931) denies a clear link between the occurrence of spinal abnormalities and backaches in a particular individual, spinal variations such as transitional lumbar vertebra and rudimentary rib have been linked by MacGibbon and Farfan (1979) to low lumbar

degeneration and its subsequent clinical impact. Gill and White (1955) also mention a correlation between transitional last lumbar vertebra and lower back pain. They describe a smaller sagittal spinal canal dimension in cases of a transitional last lumbar vertebra. Already Philipp (1932) linked the occurrence of sacral pain and the presence of sacralisation of the lower lumbar spine. Willis (1924; 1929) and Gill and White (1955) already highlighted the importance of a link between the presence of low lumbar vertebral anomalies and the occurrence of back pain. Therefore, it is essential to recapitulate some of the major spinal pathologies, which may have at least a partial evolutionary background and may help to better define the true normal range of spinal morphology.

Microevolutionary and secular trends in human anatomy

The term "secular trend" is linguistically derived from the Latin word *saeculum* meaning a generation. Therefore, secular trends describe short-term changes especially of morphological traits.

Humans are in evolutionary terms actors, which do not fully reflect their active participation (Henneberg, 1997). Henneberg (1997) describes the process of evolution as a feedback regulated by interactions between environment, technology, society and the human body. He also states, that, since our environment is self-changing and, additionally, influenced by us too, our anatomy may be adapted to technology as well. For him society and technology are acting as sieves between the human body and its environment. Particularly, modern lifestyle with its unique aspects of workload or sports activities does have an influence. Its medical significance is repeatedly underestimated.

Morphologic body changes occurring in the modern *Homo sapiens* may fall within various etiological categories such as anagenetic or cladogenetic microevolution

(Wiercinski, 1979). New selective forces, mutagenic agents, genetic intermixtures and environmental conditions act differently on the human body.

Various influences like variation of selective pressures, exchange of genes, environment e. g., climate as in the case of the altered prevalence rate of the lateral internal thoracic artery (Surtees *et al.*, 1989a; Surtees *et al.*, 1989b; Henneberg, 1992), or change of socio-economical structures, such as from hunter-gathering societies to more settled communities e.g., in the Late Paleolithic-Mesolithic transition period in Central Europe, have an impact on human anatomy, metabolism and behaviour.

Especially, gracilisation of the human body, a structural reduction of its size and bony robusticity, has been shown since the Late Paleolithic in European samples (Schwidetzky, 1962; Schwidetzky, 1967; Schwidetzky, 1969; Schwidetzky, 1972; Schwidetzky and Rösing, 1976; Vallois and de Félice, 1977; Frayer, 1980; Frayer, 1981; Wurm, 1982; Frayer, 1984; Schwidetzky and Rösing, 1984; Jacobs, 1985a; Jacobs, 1985b; Schwidetzky and Rösing, 1989; Ruff *et al.*, 1993; Mathers and Henneberg, 1996; Ruff *et al.*, 1997; Trinkaus, 1997). The advantage, in terms of energetic fitness, of having more gracile bodies has already been highlighted as a possible underlying factor (Frayer, 1981; Frayer, 1984; Henneberg and Steyn, 1995). Wurm (1982) describes a decrease in stature in historic times based on the assumption of etiologically related decreased animal protein intake. Contrary, Larsen (1981) doubts for a historic American sample the primary role of altered protein intake in causing a decrease of postcranial size and robusticity, blaming diminished mechanical load to be more likely responsible. This negative secular trend, as found in Europe, is only reversed since the early 20th century by a positive temporal trend in increased stature only in the Northern Hemisphere of still debated etiology. As one of the few exceptions, no secular stature increase have been

described in a sample of indigenous South Australians (Pretty *et al.*, 1998). Also, poor rates of trends have been found among white Australians and South Africans (Henneberg and Van den Berg, 1990; Henneberg, 2000; Henneberg, 2001b).

For Europe, Jacobs (1985b) found a significant decrease of approximately 6% in long bone sizes, stronger expressed in females than in males, during the cultural transition period from Late Upper Paleolithic to Mesolithic. Also Formicola (1983) describes for Italian samples a decrease of individual stature from Upper Paleolithic to the Bronze age. Frayer (1981) mentions a similar decrease in general body size of 5.2%, more visible than alterations of limb proportions, which are more prominent in males than females. In another study, including an expanded Mesolithic and Neolithic sample size, Frayer (1984) found again obvious trends of stature changes in the European Holocene. Individual stature decreased from the Late Upper Paleolithic until the Neolithic period for both males and females by 4.5% and 3.2% respectively. From the Neolithic until the most modern times, there is an increase of individual stature. Frayer (1984) found the increase for both sexes to be similar of approximately 4.3%. Surprisingly, according to him, even most modern males are still smaller than their Late Upper Paleolithic modern *Homo sapiens* ancestors, whereas for females it seems to be the opposite. In addition, the Late Upper Paleolithic European inhabitants were more robust. According to Frayer (1981) most of the long bone alterations obviously occurred between Pre-Würm and Würm period, not later at its transition to the Post-Würm time. During this second transition, males stabilize whereas females continued a non-significant decrease in long bone measurements. Jacobs (1985b) detected similar trends for the diaphyseal measurements. According to him, in males humeral robusticity increased, unlike femoral robusticity, from Pre-Würm to Late Würm times. Jacobs (1985b) found an opposite trend for these

two indices for the transition period from Late Würm to Post Würm times in males. Most of the robusticity indices for males increased between the Upper Paleolithic and Mesolithic period, which is not the case for females. For females, between Pre-Würm and Late Würm time there was an increase in humeral robusticity, up by more than 6%, and a slight decrease in femoral robusticity, whereas from Late Würm to Post-Würm both robusticities decreased (Jacobs, 1985b). Jacobs (1985b) describes a decrease in individual male body size mostly within the Upper Paleolithic period and not at the transition to the Mesolithic time, whereas females showed a continuous reduction. Also body proportions changed during the transition period from Pre- to Post- Würm times in Europe with humerus relative to stature becoming smaller for either sex (Jacobs, 1985b). Limb proportions in Europe did not change according to Frayer (1981). General limb reduction was more prominent for males, explainable by the higher impact of altered hunting conditions, with an 8.8% decrease for male humerus, 7.5% for female humerus, 7.6% for male femur and 4.5% for female femur, respectively. General stature reduced towards Mesolithic with 5.5% for males and 3.4% for females. Only with the start of the Mesolithic, at least for males, the stature changed significantly, while being mostly stable for the major Paleolithic periods (Frayer, 1981). Jacobs (1985b) found no such expected decrease of upper limb robusticity, due to the introduction of the atl-atl and bow and arrow, between Late Upper Paleolithic and Mesolithic in males, but describes one in females. Thus, Jacobs (1985b) explains these skeletal alterations to be more linked to nutritional changes and climatic adaptations, possibly towards a colder environment, than resulting from technological changes only.

Sexual dimorphism is an important measure to evaluate the ongoing interactions between a particular environment and the body morphology. Frayer (1980) addressed in

depth the aspect of changing cranial and postcranial sexual dimorphism. He found for cranial, dental and postcranial morphologies a general trend towards gracilisation since the Late Pleistocene, as initially reported by Weidenreich (1945). For the first transition from the Late Upper Paleolithic towards Mesolithic, the sexual dimorphism decreased mostly due to male stature decrease, whereas for the time period from Mesolithic to Neolithic, it was supposed to be due to relative increase in female stature. The present day sexual dimorphism in stature is reported to be 7.3%, mainly due to a little higher male stature increase (Frayer, 1980). Since modern females are minimally taller than their Late Upper Paleolithic counterparts, with males of these two epochs being roughly of the same stature, the sexual dimorphism in our days is slightly smaller than it was at Late Upper Paleolithic times (Frayer, 1980). Sexual dimorphism of humerus and femur length was highest for both sexes in the Pre-Würm period, followed by the Würm period with its lowest values for the Late Würm period (Jacobs, 1985b). Sexual dimorphism of humeral and femur robusticity was Jacobs, the highest for both in Post-Würm period, followed by the Late Würm, period in the case of the humeral robusticity, whereas the Pre-Würm period values were higher than the Late Würm period ones for the sexual dimorphism of the femur robusticity (Jacobs, 1985b). In general, sexual dimorphism was found to be more prominent in the Post-Würm period than in its Pre-Würm and Late Würm counterparts. Formicola (1983) describe in Bronze Age Italian samples a sexual dimorphism of approximately 7% in individual stature. He thinks that the sexual dimorphism at the Neolithic and Bronze Age in his samples was similar to modern one. Sexual dimorphism in the Upper Paleolithic and Mesolithic time could have been more strongly expressed (Formicola, 1983).

For the particular situation of Europe, since the Neolithic, it has been found that mostly decreasing levels of natural selection and further similarities of cultural environments, rather than migration and its linked gene exchange only, lead to an increased intra-group and decreased inter-group variability in morphological traits (Henneberg *et al.*, 1978).

Microevolutionary changes, occurring in short well-defined historic time periods, have been shown for various anatomical characteristics e.g., the increase of incidence of the median artery of the forearm (Henneberg and George, 1995), the occurrence of hyperostosis frontalis interna (Hershkovitz *et al.*, 1999; Rühli and Henneberg, 2002) or presence of non-osseous tarsal coalitions (Rühli *et al.*, 2003). Microevolutionary trends as expressed in their significant morphological changes, within short periods of time even question the understanding of modern human origin such as the replacement hypothesis, or the validity of any taxonomic definition of modern humans in terms of objectively measurable characteristics (Henneberg, 2001a).

Surprisingly, microevolutionary changes of the spine seem to be a neglected research area (Jankauskas, 1994). Some possible secular trends in frequency of spinal pathologies have been reported, such as the increasing prevalence of spina bifida occulta (Henneberg and Henneberg, 1999) or the prevalence of spondylarthropathy in baboons (Rothschild and Rothschild, 1996). Larsen (1980; 1981; 1982) reported a significant decrease in degenerative spinal joint diseases linked to a cultural shift towards agricultural lifestyle in an American coastal region, whereas Minne *et al.* (1988) discuss in their X-ray based study the influence of the secular increase in body height in the last century and its impact on spinal morphometry. They describe an increase of vertebral

body height, for the last 110 years and for Th4 to L5 only, of 86 mm, with no alterations, at least relative to their standard vertebra at Th4.

Nevertheless, according to Jankauskas (1994), there is a lack of microevolutionary and inter-populational studies of the human vertebral column. Just very limited spinal microevolutionary approaches have been published so far. Secular trends of vertebral body size (Clark *et al.*, 1985; Jankauskas, 1994) or neural canal dimensions (Piontek and Budzynska, 1972; Clark *et al.*, 1985; Tatarek, 2001) have been so far investigated on limited samples only.

Furthermore, according to Jankauskas (1994), no clear definition of the human spinal osteometry and its variability exists. This is in particular striking since microevolutionary trends for other major body parts such as skull size (Henneberg, 1988; Henneberg and Steyn, 1993; Ross and Henneberg, 1995) or stature and postcranial skeletal dimensions (Schwidetzky, 1962; Frayer, 1980; Larsen, 1980; Larsen, 1981; Larsen, 1982; Formicola, 1983; Frayer, 1984; Jacobs, 1985a; Ruff, 1994; Formicola and Giannecchini, 1999) have already been addressed in a plethora of reports.

As other possible causes of recent secular trends, genetic factors or their products acting during early stages of ontogeny, most likely *in utero,* have been suggested (Henneberg, 2001b). Furthermore, Henneberg (2001b) names vaccines, or food containing chemical products interfering with individual growth as additional possible underlying origins of this secular trend in the most modern times.

To summarize, surprisingly no secular trend of the non-pathologic vertebral column has so far been widely studied. *Hitherto*, in the most similar studies, Tatarek (2001) focused just on the lumbar levels, while Jankauskas (1994) included not only a limited particular Eastern European area, but also choose temporally limited samples

from the 1st and 2nd millennium A.D. only. Both studies (Jankauskas, 1994; Tatarek, 2001) were, additionally, small in number of spinal measurements taken on each individual.

No investigation focusing on microevolutionary issues on all major levels of the human vertebral column and consisting of a sample dating back to European Late Pleistocene has been published so far. Furthermore, a combined anthropological and clinical perspective including the morphometric spinal variation as well as the influence of sex and individual age on it, in particular in such a historic sample, has never been fully explored before.

Aim of the study

The aim of this study is to assess and interpret osteometric measures of a number of human spinal landmarks on all major vertebral levels that is cervical, thoracic and lumbar, in Central-Western European skeletal samples dating from the Late Pleistocene to most modern times. The data will be explored with a particular focus on the influence of sex and individual age as well as possible underlying secular and microevolutionary trends. Possible clinical implications will be addressed too.

Hypothesis to be tested

The purpose of this study is to test the null hypothesis that there is no significant change in selected osteometric traits of the human spine in terms of sex and individual age as well as from the Late Pleistocene to modern times in Central-Western Europe.

Material

Dry vertebrae of 348 individuals of both sexes have been included into the study; see also Table 3 for the list of selected individuals or samples, for the complete set of original data see appendix 2 and for a published abstract on the data of the present study see appendix 15. Selection criteria for samples were primarily being of Central-Western European origin and providing easy accessibility. A list of major samples represented could be found in Figure 3. The accessibility was usually achieved through personal consent from the collection curator, who also mostly supplied main references and the collection list, with recorded individual sex and estimated age of the chosen skeletons. Only unarticulated vertebral columns were used. In case of fragmented bones, only those whose reconstruction could be done without any apparent size or shape alterations have been selected.

All major historic time periods in Europe since Late Pleistocene are represented, with the exception of Iron Age and Roman period, when body cremation was the most popular burial practice in Europe (Schwidetzky, 1972; Schwidetzky and Rösing, 1976). Years before present (BP) were calculated from 2000 A.D. backwards. The whole sample (Figure 4) was divided for selected data analysis in three major time groups (Figure 5), Neolithic / Bronze Age, Medieval and Modern, respectively. By doing so, the single individuals from Paleolithic and Mesolithic times were neglected.

The major time periods for Central Europe background are assumed as follows, mostly according to Straus (1995):

Pleistocene	Middle Paleolithic	100,000 – 40,000 B.C.
	Late Paleolithic	40,000 – 10,000 B.C.
	Early Upper Paleolithic	until 30,000 B.C.

	Middle Upper Paleolithic	30,000 B.C. – 20,000 B.C.
	Late Upper Paleolithic	20,000 B.C. – 10,000 B.C.
Holocene	Mesolithic	10,000 B.C. – 4500 B.C.
	Neolithic	4500 – 2000 B.C.
	Bronze Age	2000 – 800 B.C.
	Old Iron Age (*Hallstatt*)	800 – 500 B.C.
	New Iron Age (*La Tène*)	500 B.C. – 0 A.D.
	Roman	0 A.D. – 400 A.D.
	Early Medieval	400 – 900 A.D.
	Classic Medieval	900 – 1100 A.D.
	Late Medieval	1100 – 1500 A.D.
	Modern Times	after 1500 A.D.

Individual age was known for each skeleton of the "St. Johann" and "Geneva" samples. For the other samples, individual age was recorded based on the provided collection lists. For most of the data analysis individuals were categorized, according to their estimated core age range, into the three main age groups: adult (20-39 years of age), mature (40-59 years of age) and senile (60 years and older), respectively (Figure 6). If the core age range of an individual covered more than one major age group, the individual was fractioned into these groups according its likelihood to be within each age group. For example, an individual with the assumed core age of 20-50 years would be counted as 0.67 in the adult and 0.33 in the mature age group.

The geographic background of the selected samples was from Southern Germany, Switzerland, Austria and France. A geographic overview of the origin of the samples could be found in Figure 7.

Table 3: Individuals / samples included in the present study

SAMPLE / SPECIMEN	N – SEX (TOTAL: 179m, 169f)	YEARS BP	CURRENT LOCATION	SELECTED REFERENCES
La Ferrassie 1 ***(Homo sapiens neandertalensis)***	**1 - m**	30,000	Musée de l'Homme, Paris (France)	(Oakley *et al.*, 1971; Heim, 1976; Stringer *et al.*, 1984)
La Chapelle-aux-Saints 1 ***(Homo sapiens neandertalensis)***	**1 - m**	30,000	Musée de l'Homme, Paris	(Oakley *et al.*, 1971; Stringer *et al.*, 1984; Trinkaus, 1985)
Cro-Magnon 1, 2	**1 - m, 1 - f**	25,000	Musée de l'Homme, Paris	(Oakley *et al.*, 1971; Stringer *et al.*, 1984)
Abri Pataud 6	**1 - m**	18,250	Musée de l'Homme, Paris	(Oakley *et al.*, 1971; Stringer *et al.*, 1984)
Neuessing	**1 - m**	18,200	Anthropologische Staatssammlung, München (Germany)	(Oakley *et al.*, 1971; Schröter, 1977)
Veyrier	**1 - m**	12,000	Département d'Anthropologie, Université de Genève (Switzerland)	(Pittard and Sauter, 1945; Oakley *et al.*, 1971)
Le Bichon	**1 - m**	11,700	Latènium, Hauterive (Switzerland)	(Sauter, 1956; Oakley *et al.*, 1971; Morel, 1993)
Gramat 1	**1 - m**	8000	Institut de la Paléontologie Humaine, Paris	(Newell *et al.*, 1979; Boden *et al.*, 1990)
Vaihingen / Enz	**4 - m, 5 - f**	7200	Anthropologisches Forschungsinstitut, Aesch (Switzerland)	-
Wandersleben	**15 - m, 26 - f**	7000	Zentrum Anatomie, Georg-August-Universität, Göttingen (Germany)	(Carli-Thiele, 1996)

Hoëdic 8, 9	**1 - m, 1 - f**	6600	Institut de la Paléontologie Humaine, Paris	(Vallois and de Félice, 1977; Newell *et al.*, 1979)
Téviec 1, 16	**1 - m, 1 - f**	6600	Institut de la Paléontologie Humaine, Paris	(Newell *et al.*, 1979; Boden *et al.*, 1990)
Birsmatten	**1 - f**	6300	Kantonsmuseum Basel-Land, Liestal (Switzerland)	(Sedlmeier and Kaufmann, 1996)
Hainburg	**17 - m, 23 - f**	3800 – 3500	Naturhistorisches Museum, Wien (Austria)	(Ehgartner, 1959)
Straubing	**37 - m, 44 - f**	1500 – 1300	Zentrum Anatomie, Georg-August-Universität, Göttingen	(Kreutz, 1997)
Aesch	**9 - m, 5 - f**	1370 – 1300	Anthropologisches Forschungsinstitut, Aesch	-
Barbing	**15 - m, 12 - f**	1300	Zentrum Anatomie, Georg-August-Universität, Göttingen	-
Winterthur	**23 - m, 13 - f**	950 - 435	Anthropologisches Institut, Universität Zürich (Switzerland)	(Jäggi *et al.*, 1993)
Chur	**8 - m, 7 - f**	750 - 550	Anthropologisches Forschungsinstitut, Aesch	-
St. Johann	**20 - m, 17 - f**	228 - 163	Naturhistorisches Museum, Basel (Switzerland)	(Etter, 1988; Etter and Lörcher, 1993)
"Geneva"*	**5 - m, 4 - f**	135 - 80	Département d'Anthropologie, Université de Genève	-
"Geneva"*	**9 - m, 4 - f**	133 - 80	Département d'Anthropologie, Université de Genève	-
"Geneva"*	**5 - m, 3 - f**	120 - 66	Département d'Anthropologie, Université de Genève	-
"Geneva"*	**2 - m, 2 - f**	106 - 85	Département d'Anthropologie, Université de Genève	-

** villages Apples, Bex, La Sarraz and Saint-Prex summarized for reasons of anonymity*

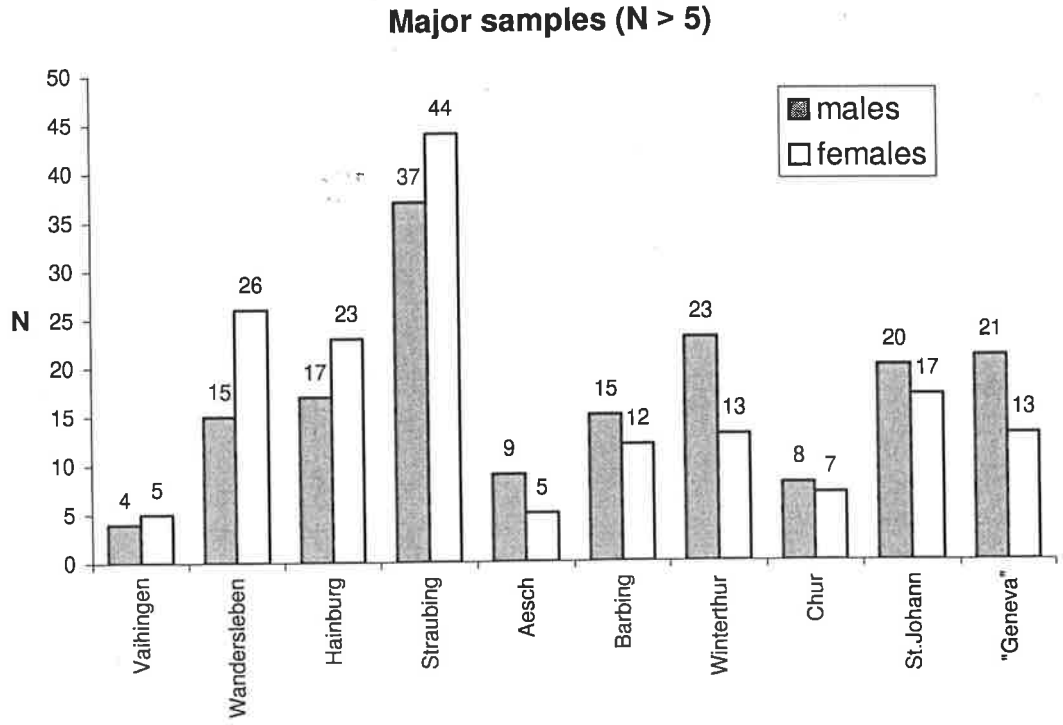


Figure 3: Major samples examined

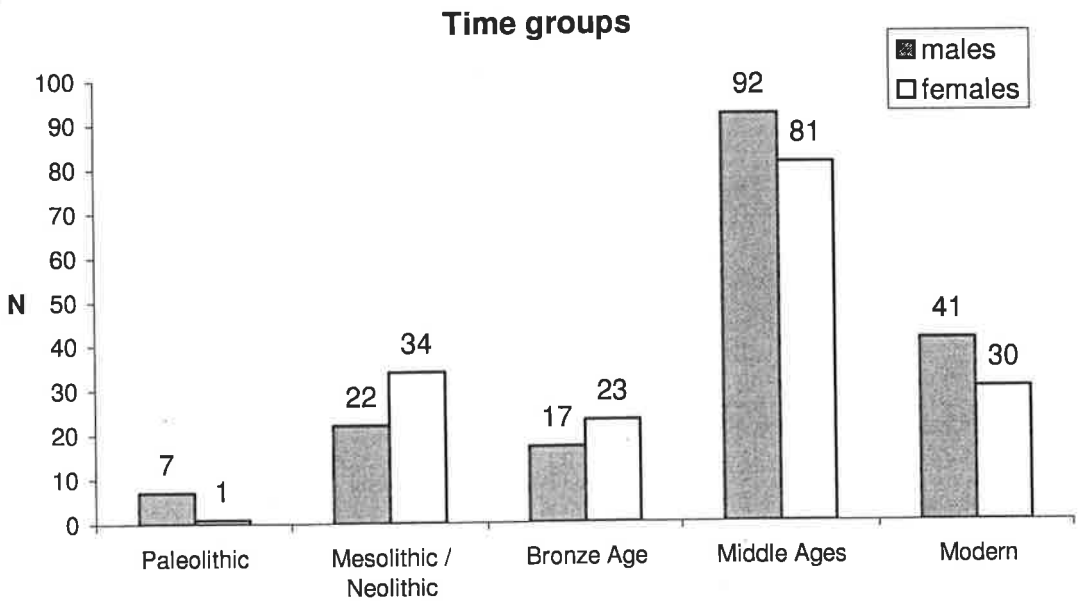


Figure 4: Historic age groups (time groups) represented in the whole sample

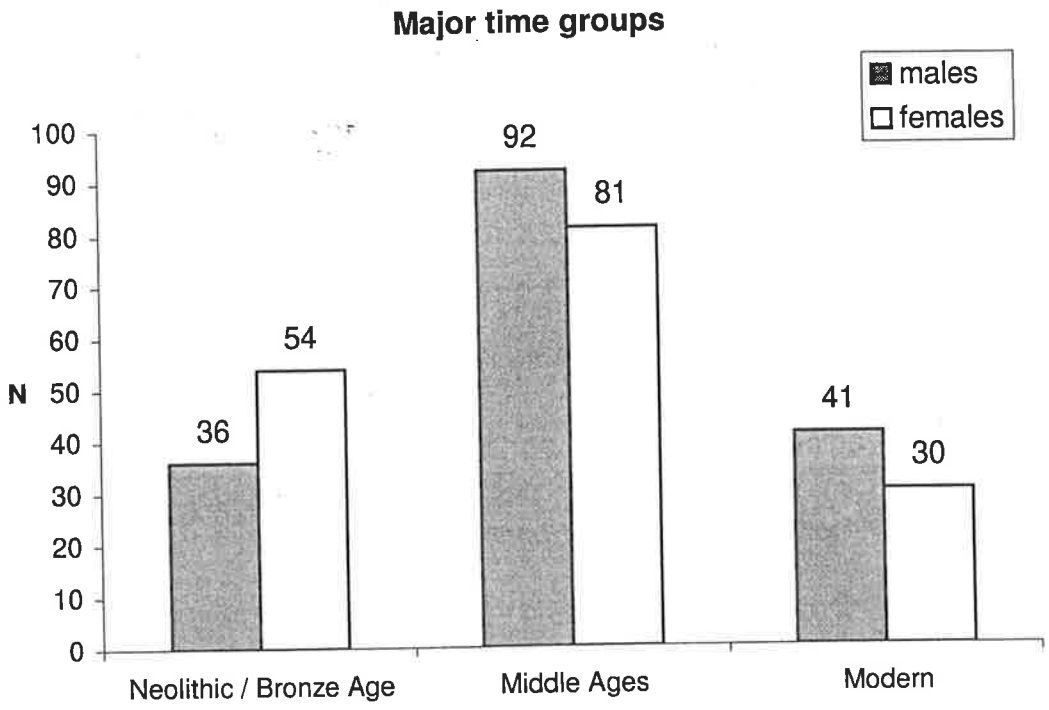


Figure 5: Major time groups represented in the whole sample

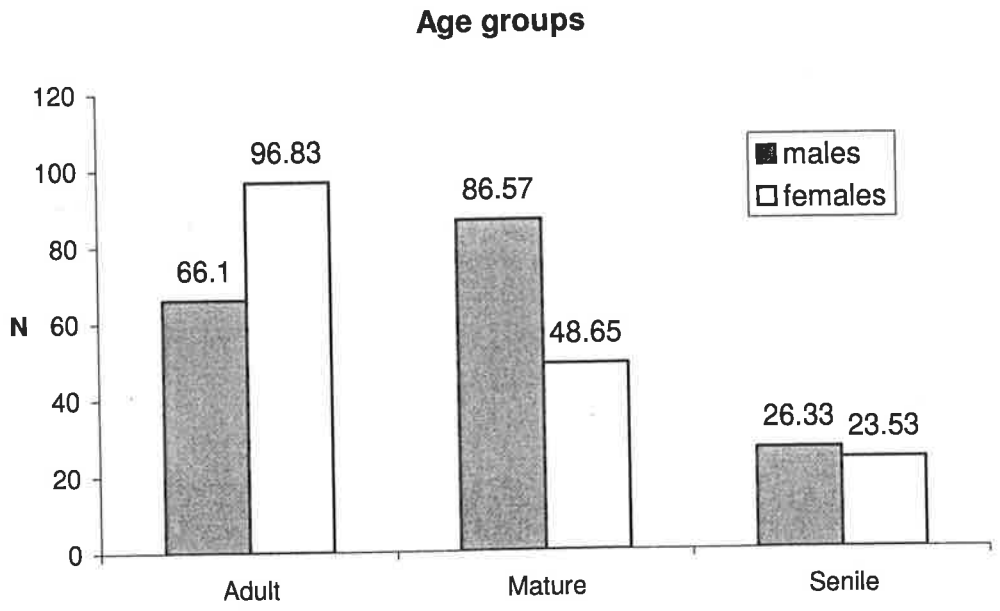


Figure 6: Age groups distribution in the whole sample

Supplementary information on the samples

The La Ferrassie 1 individual is considered an adult male Neandertal of approximately 40-50 years of age. He was discovered in 1909 in Savignac du Bugue, 40 km southeast of Périgueux in the Dordogne Region of France and most likely dates to the Würm II period. A reference list of the suggested chronostratigraphic dates of the various Würm periods can be found elsewhere (Smith, 1984). His spine is of general high robusticity similar to the one of the La Chapelle-aux-Saints 1 Neandertal individual. It represents one of the most complete preserved Neandertal vertebral columns (Oakley *et al.*, 1971; Heim, 1976; Stringer *et al.*, 1984; Riel-Salvatore and Clark, 2001).

The La Chapelle-aux-Saints 1 individual, a holotype of the *Homo chapellensis* and supposed to be a Neandertal, was found in 1908 near Corrèze in Central–Southern France. The male adult individual of approximately 40-50 years of age is linked to the Würm II period. This individual was supposed to be 164 cm in height and of a body weight of 70 kg. The vertebral column of this individual drew attention in earlier times, but the view of his apparently primitive anthropoid-like neck is less supported nowadays, as it was in the times after its discovery (Stewart, 1962; Oakley *et al.*, 1971; Stringer *et al.*, 1984; Trinkaus, 1985; Ruff, 1994; Riel-Salvatore and Clark, 2001). Despite its arthritic changes of the cervical and thoracic spine (Trinkaus, 1985), this individual was included into this series due to its historic importance.

The Cro-Magnon individuals, anatomically modern *Homo sapiens*, were discovered in 1868 near the station Les Eyzies de Tayac, approximately 25 km northwest from Sarlat in the Dordogne Region in France and date to the Würm III

period. Cro-Magnon 1, also called "the Veillard", is the holotype of *Homo spelaeus* and was supposed to be a male of at least 45 years of age. Cro-Magnon 2 is believed to be an adult female of approximately 20-30 years (Oakley *et al.*, 1971; Stringer *et al.*, 1984; Riel-Salvatore and Clark, 2001).

The Abri Pataud 6 individual, apparently an adult male, was excavated in 1963 in Les Eyzies, 25 km north-west of Sarlat in the Dordogne Region in South-Western France (Oakley *et al.*, 1971; Stringer *et al.*, 1984).

The Neuessing *2* individual was found in 1913 in the Altmühl Valley, approximately 25 km southwest from Regensburg, Southern Germany. It was dated to the *Weichselian*-Würm period and is supposed to be an adult male individual, of approximately 30 years (Oakley *et al.*, 1971).

The Late Paleolithic Magdalenian type, Late Würm period, Veyrier skeleton was discovered in 1916 in Veyrier in the Haute-Savoy region in France, next to the actual Swiss border. His living stature is estimated to be 169 cm, which makes him shorter than the average Cro-Magnon humans, but still larger than the Magdalenians and most European Mesolithic and Western European Neolithic people. Humeral and femoral robusticity are both small (Pittard and Sauter, 1945; Oakley *et al.*, 1971).

The Le Bichon individual, which was found in a cave at an altitude of approximately 850 meters above sea level in 1956 next to La Chaux-de-Fonds, Western Switzerland, is the oldest preserved individual of nowadays Swiss geographic background and belongs to the Late Paleolithic Cro-Magnon type. His cause of death, as a side remark, was recently reconstructed to be a hunting accident (Morel, 1993).

Although that his stature could not have been completely reconstructed, the individual was apparently not very tall (Sauter, 1956; Oakley *et al.*, 1971).

Hoëdic is a Mesolithic site of nine adult individual skeletons, excavated in the 1930's and located on a small island at the Bretagne, on the North West coast of France.

Téviec is a Mesolithic series, possibly slightly older than the Hoëdic site, consisting of 15 adult individuals situated in similar environment, and 32 km further in North East direction. This site was excavated primarily in the late 1920's. Both islands, Téviec and Hoëdic, were supposed to be even easier accessible today than in the Mesolithic, most likely by a dry walk from the mainland. The Hoëdic individuals seem to be not of massive robusticity, which is similar to the Téviec individuals. Apparently in one of the nine Hoëdic graves, an individual was found with six lumbar vertebrae. In addition, the Téviec sample contains one individual with such an increased number of vertebrae. The individuals from both Mesolithic samples are of small stature, at least in comparison with East Europeans of the Late Paleolithic, but they are comparable to other Mesolithic people of similar geographic background. Individual stature was for the Hoëdic males on average 160 cm and for the females 152 cm, whereas it was 159 cm for the Téviec males and 151 cm for females, respectively. The two samples were classified to be modern humans of the "Téviec–island" type (Vallois and de Félice, 1977).

In comparison, the Gramat male from mid-South-Central France was reconstructed to be of 165 cm height and of a remarkable femoral robusticity, but not of high humeral robusticity: He seems to be an exceptional human of the "Téviec-continental" type (Vallois and de Félice, 1977). The Gramat male individual is a complete skeleton of the Holocene period discovered in 1928 in Le Cuzouln de Gramat,

approximately 55 km north-east of Cahors in the Dordogne region of France (Oakley *et al.*, 1971). For a precise description of the distinctive skeletal characteristics of the two Mesolithic prototypes, "Téviec-continental" and "Téviec–island", see Vallois and de Félice (1977).

The Holocene Birsmatten individual, most likely to be a female according to new anthropological assessments, was found in 1944 in Nenzlingen (Northern Switzerland) and is the only Mesolithic body burial in nowadays Switzerland. The skeleton is of remarkable preservation for its historic age and individual stature was calculated to be of approximately 160 cm (Sedlmeier and Kaufmann, 1996).

Wandersleben is a Neolithic *Linienbandkeramiker* (linear pottery) - culture settlement, located between Gotha and Erfurt in present-day Germany. The whole sample consists of approximately 200 individuals, representing one of the largest known Central European classic settled agricultural lifestyle societies, but an archaeological report of this excavation is still not yet published (Carli-Thiele, 1996).

This situation is similar for the sample of Vaihingen, which is also a linear pottery settlement (Early Flomborn and Middle linear pottery phase) in nowadays Vaihingen an der Enz, in the Neckar Region next to Stuttgart (Baden-Württemberg, Southern Germany) of generally excellent preservation. A final report on this old Neolithic agricultural site with approximately 100 flexed burials has not yet been published; preliminary information could be found at the following internet-website: http://home.bawue.de/~wmwerner/grabung/vaih.html.

Hainburg is a burial ground of 253 skeletons from the Early Bronze Age *Wieselburger* - culture, excavated in the late 1920`s as well as in the late 1930`s. The

site lies 54 km east from Vienna at the banks of the river Danube. The anthropologic record showed mainly autochthonous inhabitants, also some foreigners, most likely from the further Western Neolithic *Glockenbecher* - culture, and some inhabitants of unclear geographic background. In general, beside unfortunate losses during World War II, the Hainburg material is of high preservation quality. Most of the individuals seem to be in the age group of 30-40 years. Average height for males was approximately 165 cm and for females approximately 153 cm, respectively (Ehgartner, 1959).

The Straubing sample, remains of a Bajuwar settlement located close to Regensburg in Southern Germany and next to the river Danube, seems to represent a mixture of Non-Francs Germanics and Romanic sub-groups. It was excavated in the early 1980's and consists of approximately 650 adult individuals, spanning a time range from the 5th to the 7th century A.D., the Early Medieval Merrovingian time (Kreutz, 1997).

The St. Johann individuals excavated in the late 1980's in downtown Basel, North-western Switzerland, with burial dates from 1845 until 1868, are part of a hospital cemetery representing an early modern urban society. Most individuals are known by name and age. Available death records list cause of death, local geographic origin as well as in some cases professions of the deceased. The majority of the recorded occupations were craftsmen and textile industrial workers for males, and maids or house wives for females. Listed causes of death for both sexes were mainly of non-osseous infectious nature, such as pulmonary tuberculosis or abdominal typhus (Etter, 1988; Etter and Lörcher, 1993).

The individuals from the samples of La Sarraz, Bex, Saint-Prex and Apples, all originate from modern Western Switzerland. These individuals also have records with

listed age at death, sex and profession. They lived in four Swiss villages with a mostly farming background, but some had a similar professional background e.g., craftsmen or light industrial workers, as the individuals of St. Johann sample.

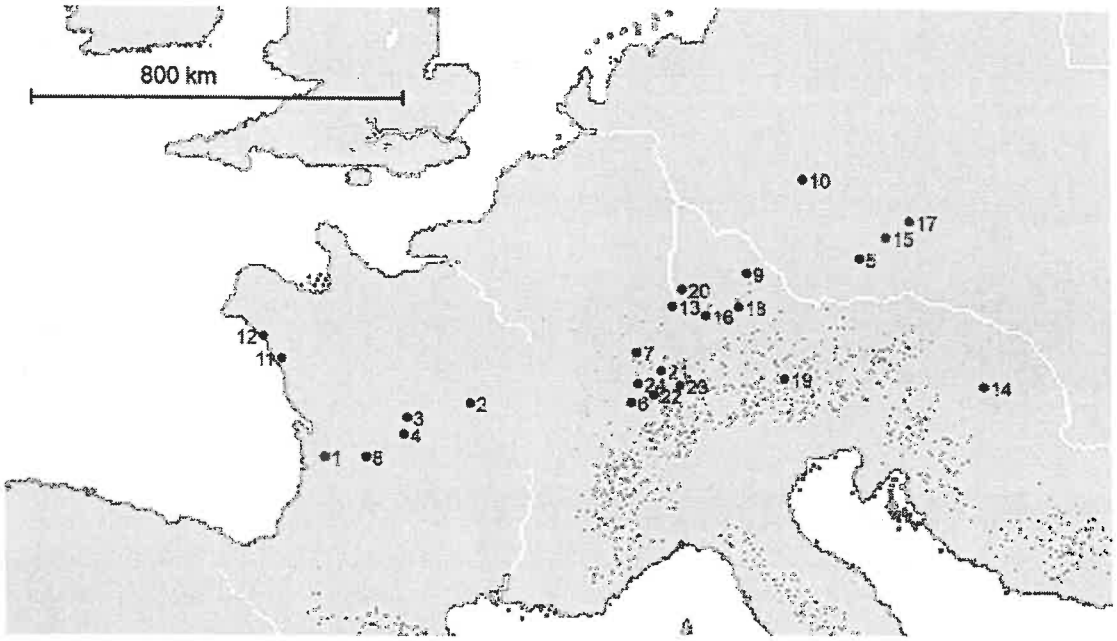


Figure 7: Map of Central-Western Europe with sample origins:

1) La Ferrassie
2) La Chapelle-aux-Saints
3) Cro-Magnon
4) Abri Pataud
5) Neuessing
6) Veyrier
7) Le Bichon
8) Gramat
9) Vaihingen / Enz
10) Wandersleben
11) Hoëdic
12) Téviec
13) Birsmatten
14) Hainburg
15) Straubing
16) Aesch
17) Barbing
18) Winterthur
19) Chur
20) St. Johann
21) La Sarraz
22) Bex
23) Saint-Prex
24) Apples

Methods

Measurements

Osteometric measurements were taken on the following vertebral levels (numbered as counted from cranial):

- **3rd (CERVICAL 3** vertebra in a normal spine with 24 pre-sacral vertebrae)
- **7th (CERVICAL 7)**
- **8th (THORACIC 1)**
- **13th (THORACIC 6)**
- **17th (THORACIC 10)**
- **20th (LUMBAR 1)**
- **24th (LUMBAR 5)**

The vertebral levels were selected for the following reasons:

C3 is the first cranial vertebra with a true vertebral body; therefore, it acts as a transition vertebra between the cranial base / upper cervical spine and the main cervical spine

C7 also called *vertebra prominens* due to its outstanding spinous process; it is the last vertebra of the cervical spine, therefore, acts as a transition vertebra between two of the major spine sections

Th1 is the first thoracic vertebra; transition vertebra between the cervical and thoracic spine

Th6 is the vertebra located at the level where the thoracic kyphosis is usually most strongly developed

Th10 is the most caudal thoracic vertebra that is still directly linked with the chest by a rib-sternum connection

L1 is the first lumbar vertebra; transition vertebra between the thoracic and lumbar spine

L5 is the last lumbar vertebra; transition vertebra between the lumbar spine and the os sacrum

All selected vertebral levels, except Th6, are part of one of the transition zones highlighted in the state-of-the-art studies on spinal morphometry by Panjabi *et al.* (1991a; 1991b; 1992) or Xu *et al.* (1995). The particular focus on these transition regions was chosen, since it was assumed for this study that any osteometric alteration of the spine would be more likely to be expressed in such transition zones than in vertebrae in the middle of a spine zone. The author personally determined the vertebral levels; in cases of any doubt about correct vertebral level, the individual was excluded. Thoracic *versus* lumbar vertebrae were identified e.g., by presence of rib articulations and the orientation of zygapohyses. If an additional vertebra was present, the one that serves the above-mentioned transitory functions e.g., L6 instead of L5, was chosen. This approach is similar to the one followed by Shapiro (1993) in a morphometric spinal study, where vertebrae were selected due to their function, rather than their anatomical position.

All measurements were done on original specimens only. One single observer took all vertebral measurements, so no inter-observer error occurred. All measurements were taken twice repeatedly. If the results showed a difference of more than 0.1 mm a third measurement was performed and the average of all assessments was later used for analysis. Any bones manifesting major gross morphological abnormalities e.g., severe arthritic changes on multiple levels or diffuse idiopathic skeletal hyperostosis, were excluded. If any bone was fractured, only the ones allowing perfect re-adaptations of the broken pieces were assessed. If one side of the transverse process was missing but the other side was preserved intact, overall transverse process width was estimated by multiplying by the factor of two the distance from the intact most lateral tip to the middle of the endplate at the posterior border of the vertebral body. Minor osteophytic alterations were not a reason for exclusion, as long as they were regarded as normal age-related adaptations. Young adult individuals showing macroscopic signs of still ongoing vertebral growth were excluded.

To assess the suggested osteometric variation and possible microevolutionary trends of the human spine, a set of various measurements was performed at each chosen vertebral level; see also Table 4 and for all abbreviations used see appendix 1. In accordance with most of the earlier published major studies dealing with spinal morphometry, such as e.g., the ones by Jankauskas (1994) or Panjabi *et al.* (1991a; 1991b; 1992), dimensions of various anatomical parts of the selected vertebral levels were chosen. To determine potential alterations of the vertebral bodies, measurements of their height and main diameters were performed. To be able to detect likely alterations of the pedicles, the maximum pedicle height, was included as well. For the assessment of the osseous outline of neural pathways, the main diameters of the spinal

canal, the foramen magnum as well as the width of the intervertebral foramen were chosen to be measured.

Length and circumference of the femur and humerus were included for the assessment of individual stature as e.g., shown by Trotter and Gleser (1952) and robusticity, as already outlined e.g., by Martin (1928). One has to be aware that humerus maximum length and radius maximum length as well as femur bi-condylar length and tibia maximum length are strongly correlated not only in recent samples, but also in Neandertals and early anatomically modern humans (Trinkaus, 1981). Therefore, all findings in the measured long bones may also be generally true for the other related limb bones. Furthermore, Martin (1928) already defined the measurement of femoral head width and bi-iliac width, both indicators of individual body mass as e.g., applied by Ruff *et al.* (1997) for Pleistocene *Homo* and used in the study presented here as well.

Most of the selected measurements were performed according to the well-established osteometric definitions by Martin (1928). Martin (1928) did not define osteometric measurements for e.g., maximum transverse process width or spinous process length. The first one was done in the present study according to Hasebe (1913) and the latter one according to Schultz (1961). The maximum pedicle height was defined hereby similar as in the study by Shapiro (1993). Furthermore, a plethora of definitions for the measurement of the intervertebral foramen width and height, especially for cadaveric samples, has been defined so far; see also Figures 8 and 9 with unaltered or slightly adapted figures of earlier publications. In the present study, a measurement approach similar to the ones chosen by Amonoo-Kuofi (1985) or Ebraheim *et al.* (1997), was performed.

Table 4: Measurements used (M: numbering according to Martin 1928)

Measurement	Abbreviation
Ventral cranio-caudal diameter of vertebral body:	M1
Dorsal cranio-caudal diameter of vertebral body:	M2
Mean sagittal diameter of vertebral body:	M6
Mean transverse diameter of vertebral body:	M9
Maximum pedicle height; see also Figure 8:	PH (Shapiro, 1993)
Spinous process length:	SPL (Hasebe, 1913)
Transverse process width:	TPW (Schultz, 1961)
Cranial / caudal intervertebral foramen width; see also Figure 8 / 9:	IFCR / IFCA (Amonoo-Kuofi, 1985; Ebraheim *et al.*, 1997)
Sagittal diameter of vertebral foramen:	M10
Transverse diameter of vertebral foramen:	M11
Foramen magnum breadth:	FMM16
Foramen magnum length (*basion - opisthion*):	FMM7
Maximum length of humerus:	HLM1
Minimal circumference of humerus:	HCM7
Maximum length of femur:	FLM1
Circumference at mid-femur:	FCM8
Femoral head breadth:	FHM18
Bi-iliac width:	BIWM2

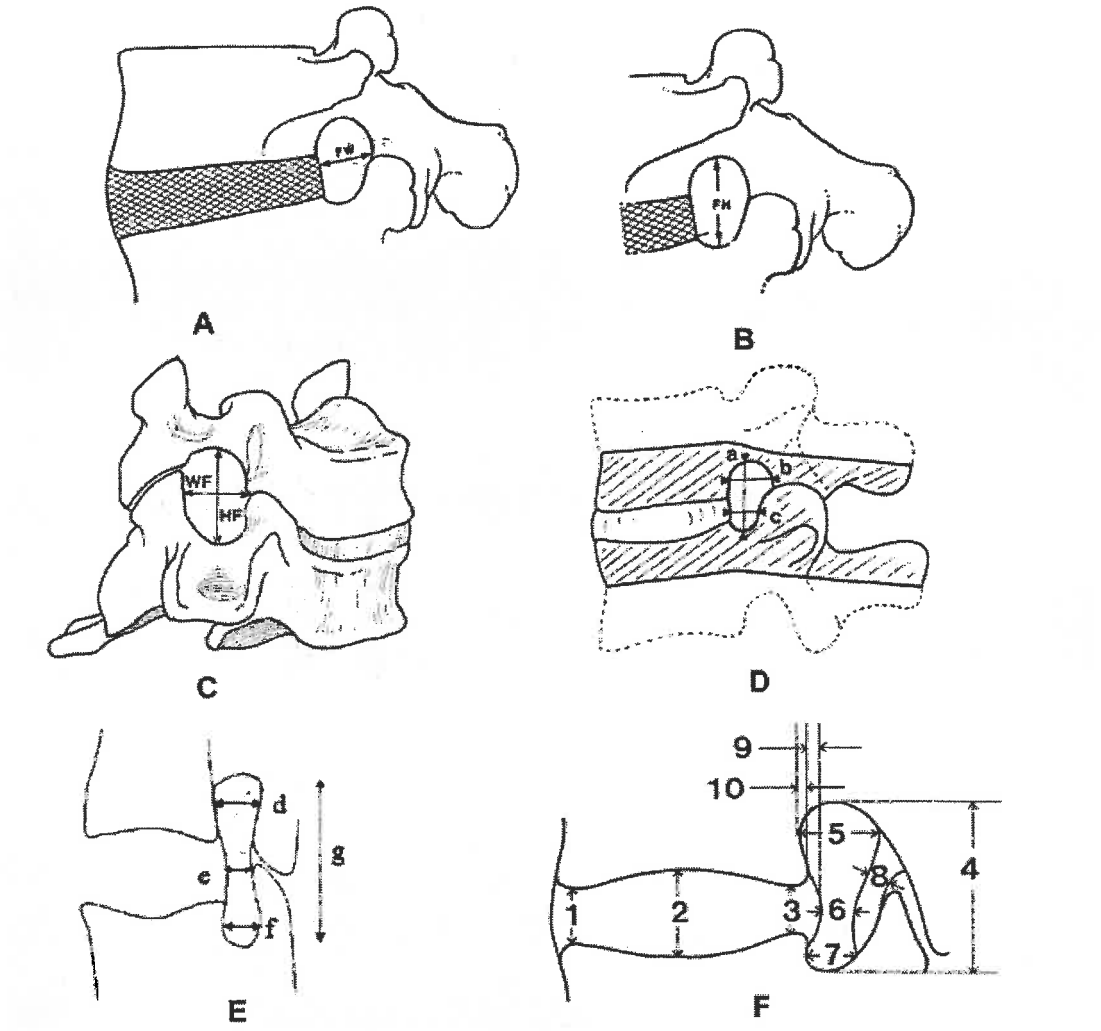


Figure 8: Lateral views of measurement definitions of the intervertebral foramen

A and B) Stephens *et al.* (1991); Lateral radiograph - FW) foraminal width, FH) foraminal height

C) Ebraheim *et al.* (1996); Hf) maximum height of foramen, Wf) maximum width of foramen

D) Mayoux-Benhamou *et al.* (1989); a) foramen height between superior and inferior surface centred in the pedicle, b) width of the superior part of the foramen, c) width of the inferior part

E) Humphreys *et al.* (1998); d) superior foraminal width, e) middle foraminal width, f) inferior foraminal width, g) foraminal height

F) Hasegawa *et al.* (1995); 1) anterior disc height, 2) mid-point disc height, 3) posterior disc height, 4) foraminal height, 5) superior foraminal width, 6) middle foraminal width, 7) inferior foraminal width, 8) horizontal width of ligamentum flavum, 9) posterior bulging of intervertebral disc, 10) width of posterior vertebral margin

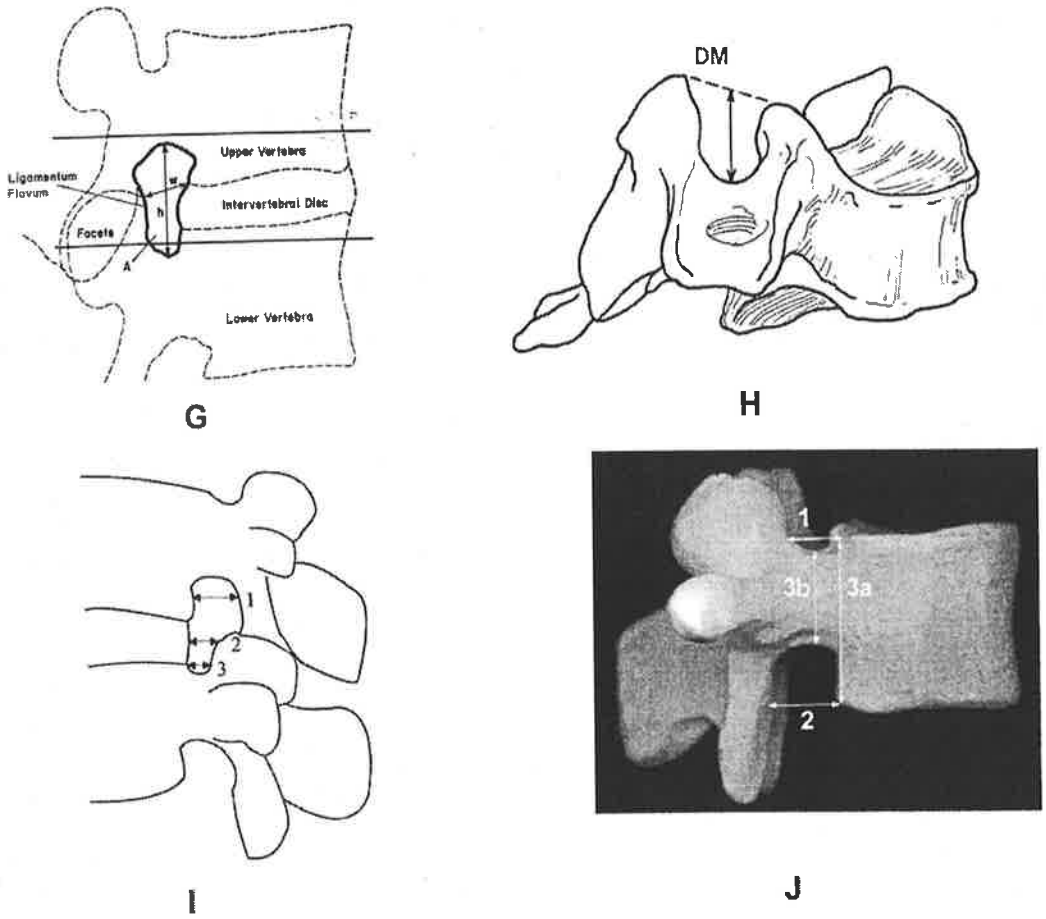


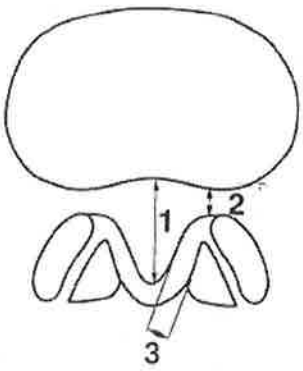
Fig. 8 (cont.): Lateral views of measurement definitions of the intervertebral foramen

G) Panjabi *et al.* (1983); A) area of the notch, h) maximum vertical space, w) minimum width of the foramen

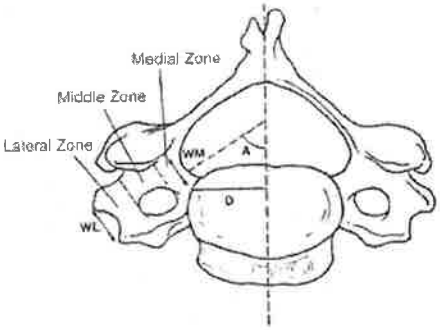
H) Ebraheim *et al.* (1996); DM) medial zone depth

I) Cinotti *et al.* (2002); 1) superior foraminal width, 2) minimum foraminal width, 3) pedicle length

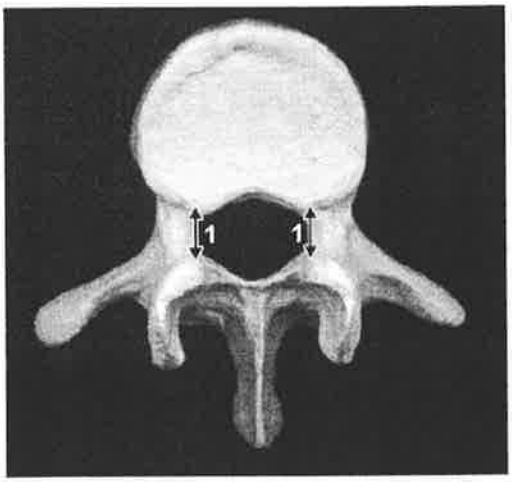
J) Present study; 1) cranial intervertebral foramen width, 2) caudal intervertebral foramen width 3a) dorsal vertebral body height, 3b) maximum pedicle height; intervertebral foramen definitions similar e.g., to Amonoo-Kuofi (1985) or Ebraheim *et al.* (1997)



A



B



C

Figure 9: Cranial views of osteometric measurement definitions of the intervertebral foramen

A) Inufusa *et al.* (1996): 1) mid-sagittal diameter of vertebral canal, 2) sub-articular sagittal canal diameter, 3) ligamentum flavum thickness
B) Ebraheim *et al.* (1996): WM) medial zone width, WL) lateral zone width, D) distance from vertebral body midline to the anterior border of the medial zone, A) angle between the nerve groove axis and the mid-sagittal plane
C) Present study: 1) intervertebral foramen width (similar for cranial and caudal measurement)

Symmetrical structures, such as the intervertebral foramen, were measured bilaterally; since, according to Marchesi *et al.* (1988), at least some of the vertebral measurements show side-dependent values of unknown significance.

Long bones measures were taken preferably on the right side, if preservation allowed it. Martin (1928) stated that the right humerus is usually longer and more massive than its left counterpart is. Therefore, the right sided long bones were chosen in this study, despite the fact that some authors use the left side to assess postcranial dimensions (Larsen, 1981). The left femur is usually bigger than the right one, whereas it is the other way round for the humerus (Martin, 1928; Trotter and Gleser, 1952). According to Pfeiffer (1980), the long bones of the non-dominant side, which is usually the left one, are less susceptible to age dependent size and robusticity changes. Nevertheless, correlations between right and left side measurements of long bones are high. According to Trotter and Gleser (1952), in white males inter-correlation among lengths of right and left femur as well as humerus is for both long bones 0.98, with mean absolute side differences for femur and humerus 0.6 mm and 0.5 mm respectively. Either long bone measurements were performed in the study presented here by the author himself, to the nearest 1 mm, or they were taken from collection references.

Paleolithic long bone and foramen magnum data were kindly provided by Holliday (T. Holliday, *pers. comm.*) or gained from other earlier published data (Martin, 1928; Trinkaus *et al.*, 1994). Sex and age of Paleolithic and Mesolithic skeletons were, in addition to the listed main references, brought in accordance with various sources (Holliday, 1997; Formicola and Giannecchini, 1999; Holliday, 1999; Riel-Salvatore and

Clark, 2001). Individuals of the Hainburg sample were assed in terms of sex, based on new estimations (B. Auerbach, *pers. comm.)* or collection references (Ehgartner, 1959).

Furthermore, the measurements used for the sagittal and transverse vertebral body diameter taken at mid-height escape most of the degenerative lesions, since these pathologies appear preferably at the level of the superior or inferior endplates. On Th6 and Th10, no cranial intervertebral foramen width could be determined. With regard to the particular anatomy of the posterior surface of the vertebral body (Larsen, 1985), it is worth noting, that in this study the sagittal vertebral body diameter was measured according to Martin (1928). In the midline of the posterior surface, the bridge of the foraminae caused by the basivertebral veins was the posterior reference point for the diameter. This point does usually slightly differ from the most concave point within the posterior surface at least of the lumbar vertebrae (Larsen, 1985).

Technical equipment

All measurements, except for long bone length, circumference and bi-iliac breadth, were taken with a sliding caliper to the nearest 0.1 mm.

Several authors (Krag *et al.*, 1988; Scoles *et al.*, 1988) pointed out that direct osteometric measurements are still the best method to determine spinal dimensions. To improve direct caliper based measurements, Ebraheim *et al.* (1996) e.g., even cut off the transverse process of the particular level. This would not be favoured for obvious reasons in historic specimens. Surprisingly, Yoo *et al.* (1992) state that a caliper-based assessment of the intervertebral foramen diameter is not accurate enough, mainly due to the measurement technique itself. Therefore, they used for their study of intervertebral

foramen size in fresh but frozen cervical cadaver spines a penetrating probe. Obviously, this would not useful for skeletal studies either.

Estimation of intra- and inter-observer error

It is crucial to know a possible intra-observer error of osteometric measurements of the vertebral column. In average this my have an extent of approximately 0.25 mm per vertebra (Todd and Pyle, 1928a; Lanier, 1939). Larsen (1985) addressed the possible error caused by an uneven vertebral surface with a possible error of up to several tenth of a millimetre. Nissan and Gilad (1986) found in their caliper based roentgenogram study, that for osseous vertebral measurements, statistical errors are of higher importance than the measuring linked errors. Nissan and Gilad (1984; 1986) observed the intra-observer error in defining skeletal landmarks in a radiological study to be of 0.5 mm or less. The average intra-observer error of measurement for a semi-automatic measurement of vertebral dimensions in conventional radiography was 1.4%, and the inter-observer error was 2.1% (Diacinti *et al.*, 1995). Kandziora *et al.* (2001) describe the error of osteometric measurements of the cervical spine to be +/- 0.08 mm in their study by using a digital ruler with a stated accuracy of 0.1 mm. They found an equal accuracy of the radiologic assessments. Hinck *et al.* (1966) describe the intra-observer error in an X-ray study of the interpediculate distance to be of 0.26 mm. Furthermore, Minne *et al.* (1988) report a low intra- and inter-observer error of measurement in their X-ray study on the normal spinal morphometry. Todd and Pyle (1928b) discussed the extent of errors between roentgenographic and wet spine morphology, as well as the intra-observer error of measurement on dry and wet spines (Todd and Pyle, 1928a). Roaf (1960) found an acceptable correlation between radiographic and *post mortem*

spinal measurements. Jacobs (1985b) lists an intra-observer error of 0.002% for lengths and 1.7% for other measurements. In comparison to earlier published data, his margin of error was 0.003% and 2.1% respectively. Therefore, Jacobs (1985b) concludes that by including published data in a personally acquired data sample, one does not significantly increase existing intra-observer errors of measurements. On the other hand, Porter *et al.* (1987) had in their ultrasound based study a mean repeatability in measuring the 15° oblique lumbar spinal canal width of 0.5 mm. In another ultrasound based study of the oblique lumbar spinal canal dimension, Porter *et al.* (1978b) found an intra- and inter-observer error of measurement of 0.2 mm. The intra-observer and inter-observer error of measurement were both 0.4 mm in another ultrasound study of the same structure (Hibbert *et al.*, 1981a). For a similar study, Legg and Gibbs (1984) report an intra-observer error of measurement of less than 0.3 mm. Surprisingly, they had consistently different values obtained than earlier published ultrasonographic assessments of the spinal canal diameter (Porter *et al.*, 1978a), explained by them to be most likely due to a systematic difference. The intra- and inter-observer coefficients of variation were approximately 2.5% and 5%, respectively, in an X-ray based morphometric study by Hermann *et al.* (1993). Furthermore, they mention the possible error in different X-ray studies caused by the fact that average subcutaneous fat thickness in selected populations varies and, therefore, by having an altered magnification factor while obtaining the X-rays, the gained data may differ slightly as well. Additional technical factors relevant especially for radiographic studies of spinal morphology are also mentioned by Hermann *et al.* (1993). In their anatomic-biomechanical study on the cadaveric lumbar spine, Fujiwara *et al.* (2001) determined the intra-observer error for

the measurement of the intervertebral foramen width to be 0.3 mm - 0.4 mm and for the intervertebral foramen height to be 0.2 mm. The inter-observer error is well known for spinal measurements in clinical imaging situations (Ullrich *et al.*, 1980; Beers *et al.*, 1985; Gallagher *et al.*, 1988; Hermann *et al.*, 1993; Wildermuth *et al.*, 1998), but this does not apply for this study due to the fact that only one observer performed all measurements. Ullrich *et al.* (1980) list the inter-observer error for linear spinal measurements by CT to be of less than 3%. Gallagher *et al.* (1988) examined the intra- and inter-observer error of measurement in a radiographic study on female spines. They found variation coefficients to be of less than 3% or 4%, respectively, for linear vertebral measurements.

The standard error of measurement for the pedicle length, as measured by Zindrick *et al.* (1987) in a radiographic measurement was for the thoracic and lumbar spine between 0.2 and 0.6 mm. For a slightly different way of osteometric measurements of the pedicle height, Marchesi *et al.* (1988) found standard errors of measurements between 0.2 mm and 0.4 mm; for the osteometric assessment of the spinal canal dimensions errors of 0.2 mm - 0.7 mm, and for the anterior and posterior vertebral body height errors between 0.2 mm and 0.5 mm. Olsewski *et al.* (1990) mention an error of measurement for pedicle height and width of 0.1 mm. Kothe *et al.* (1996) found an accuracy for the digitised measurement of pedicle slices to be 0.06 mm. Misenhimer *et al.* (1989) describe the accuracy of CT measurements of the pedicle in comparison to osteometric data to be within a third of a millimetre. Panjabi *et al.* (1991a; 1992) list in their three-dimensional morphological studies, which are largely different from the one presented here, the overall error in computing vertebral

morphology to be less than 5%, with the error in instrument location on a certain vertebral landmark to be +/- 0.5 mm. The accuracy of caliper based osteometric spinal measurements was questioned by Huizinga *et al.* (1952). Due to the lack of precision, they recommend not to use data of a higher accuracy than 1 mm. Nevertheless, it seems reasonable to assess spinal morphology by caliper measurements, as long as one is aware that there are some underlying minor methodical errors.

To evaluate possible inter- and intra-observer error in the study presented here, a special sub-project was initiated. As part of a "Commonwealth Scientific and Industrial Research Organisation" Year 12 Student Research Scheme, three inexperienced students and the author of this work measured, according to the above outlined technique, selected spinal landmarks in a series of recent vertebrae from the collection of the Department of Anatomical Sciences, the University of Adelaide. Their measurements were tested for reliability and accuracy among intra- and inter-observer. The largest intra-observer error, as indicated by the technical error of measurement, was in the inexperienced group, as seen in Figure 10, but still even inexperienced observer can reach accuracy similar to the ones of an experienced investigator.

Furthermore, if one compares selected data available from the literature with the ones obtained in this study, it can be seen that all measurements are within a range of 0.9 mm; see also Table 5. These particular measures are difficult to fully appreciate, since the study by Vallois and de Félice (1977) record the measurements to an accuracy of only 0.5 mm. The inter-observer error was for these particular measurements overall very low with just 0.05%.

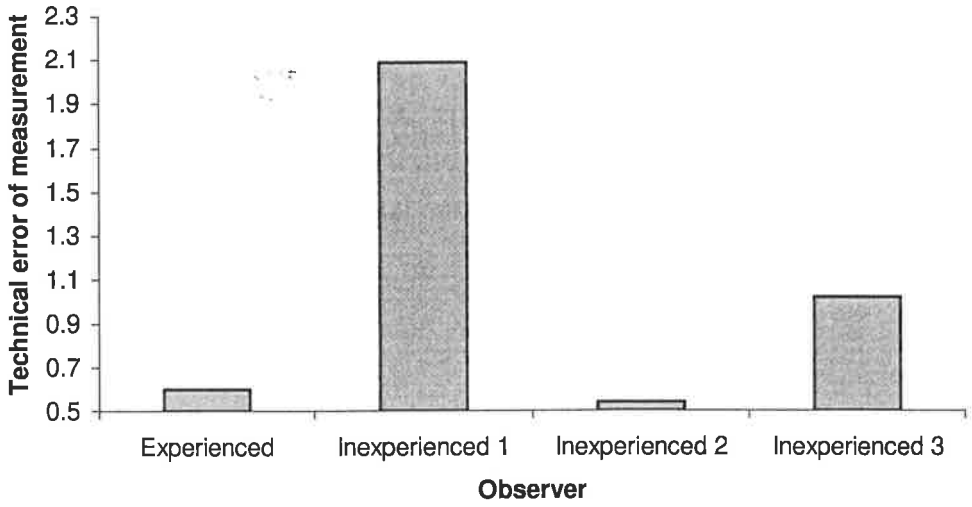


Figure 10: Technical error of measurement for selected spinal dimensions by experienced and inexperienced observers

Table 5: Inter-observer error of selected vertebral and long bone dimensions (mm) (measurements similar to Martin (1928) 1: ventral body height / maximum femur length; 2: dorsal vertebral body height; 10: sagittal diameter spinal canal; 11: transverse diameter spinal canal; 8: mid-femur circumference)

Sample	1 - Th10	2 - Th10	10 - Th10	11 - Th10	1 - L1	2 - L1	10 - L1	1 - L5	2 - L5	1- femur	8- femur	Reference
Veyrier (m)	26	30	17	21	28	29	17			461	81	Pittard and Sauter (1945)
	24.2		**18.3**	**20.7**	**28.2**	**27.2**	**18.2**			**464**	**81**	**Present study**
Téviec 16 (m)					25	29		25	23			Vallois and de Félice (1977)
					24.5	**29.8**		**28.8**	**23.1**			**Present study**
Téviec 1 (f)					21	25		21	21			Vallois and de Félice
					20.1	**24.8**		**20.7**	**21.8**			**Present study**

Examination permission

Collection accesses were approved in oral or written form by the responsible curators in advance.

Data analysis

All original data were copied by the author himself into a Microsoft® Excel 2000 (Microsoft Corporation, Redmond, WA, USA) spreadsheet. Data were checked twice for obvious mal-transcription errors. If any doubt about data persisted after double-checking with the original record sheet, the particular measurement was deleted.

It can be assumed, based on earlier reports (Minne *et al.*, 1988; Black *et al.*, 1991; Xu *et al.*, 1995), that spinal morphometric ratios follow a normal or Gaussian distribution. Therefore, measurements before the final data analysis were trimmed by deleting all data outside the range of three standard deviations. Spinous process length on C3 (C3S1) and transverse process width on level C7 (C7H1) were excluded in most data analyses due to their overall small sample size.

Statistical analyses were done by either using Microsoft® Excel 2000 or, primarily SPSS® 11.0 (SPSS Inc. Chicago, IL, USA) software. The skeletal sample was analysed separately for both sexes. The limits of two-tailed significance were estimated for $p<0.05$, with Bonferroni's correction added for measurements on multiple vertebral levels. Morphometric values were listed including means and standard deviations as well as mode, median and minimum and maximum values. Standard deviations for Table 6 were calculated as sample standard deviations, whereas for the data sets in the appendices it was defined as population standard deviations. Sexual dimorphism of measurements was assessed as a percentage difference of mean values as well as by

paired t-test. Paired t-test was also applied for analysis of side differences of spinal measurements. Correlation of variables with individual age was tested primarily on the well-recorded modern samples. Furthermore, correlations of variables with major age groups, defined as adult, mature and senile, were tested for the non-modern samples, as well as for the three major time groups, defined as Neolithic / Bronze Age, Medieval and modern, respectively. Temporal trends were considered for the whole sample, including the single individuals from the Mesolithic and Paleolithic time period. To test for the best regression model, linear, quadratic, cubic, exponential, logarithmic and power functions were assessed. One-way analysis of variance (ANOVA) was used to test for significant alterations of mean values and standard deviations of variables between the three major time groups. Principal components analysis was done for the whole sample, separately for both sexes.

A list for all used abbreviations for the spinal variables could be found in appendix 1.

Critical sample size

The critical sample size to detect morphometric measurements depends on the level of significant mean difference (E_x) between samples. It is

$$E_x = SD/\sqrt{N}$$

with $2 \cdot E_x$=mean critical difference, SD being the standard deviation, and N the number of individuals.

If a difference of +/- one SD is expected, the critical N should be 4. If a difference of a half of SD is expected a critical sample size of 16 and with a difference of a third of SD it is 36 and with a quarter SD it is 64. A discrepancy of +/- one SD is a

likely assumption of mean difference in spinal morphometry, since earlier studies found a decrease of human brain size, another part of the central nervous system, of one SD within the same explored time frame, the Holocene (Henneberg, 1988).

Modern samples

The two most modern samples; see also Table 6, the St. Johann specimens, as well as the individuals from Apples, Bex, La Sarraz and St. Prex, subsequently summarily labelled as "Geneva" sample, were selected as reference data. These so-called "modern" samples are unique. All individuals are personally known with recorded sex, age at death and mostly with background information, such as occupation and cause of death. The two samples show no significant secular trend in stature, as estimated by individual femur length ($p<0.05$: $r=0.02$), nor did femoral robusticity ($p<0.05$: $r=0.21$) alter. Both sexes in the samples showed no significant difference in age at death between the two samples ($p<0.05$; r–females = 0.05, r-males = 0.03). The samples were e.g., used to test for possible significant correlations of the variables with individual age.

Table 6: Composition of modern samples St. Johann and "Geneva", with individually known sex and age (N=71, Mean=49.4 yrs, SD=18.4 yrs)

Age group	**N males** (Mean=51.9 yrs, SD=18.6 yrs)	**N females** (Mean=45.9 yrs, SD=18.3 yrs)
20-39 yrs	13	15
40-59 yrs	14	8
>60 yrs	14	7
Total	41	30

Results

Sex and age composition of the samples

The average dating of the male sample (N=179) was approximately 2650 years BP and the one of the females (N=169) was approximately 2680 years BP. The largest subgroup for both sexes was the combined individuals of the Medieval Ages epoch. The major samples and their particular sex ratio are shown in Figure 3. The biggest single sample is the Early Medieval one from Straubing.

The skeletons were classified into three major age groups: adult (20-40 years), mature (40-60 years) and senile (older than 60 years). The distribution of the sexes in relation to these age groups can be found in Figure 6. On average, the percentage of females in the adult group is higher than for males, and the opposite can be found in the mature group. The mean of the female major age groups, as defined for adult being 1, mature being 2 and senile being 3, was 1.6 in comparison with 1.8 for males, but with the same standard deviation for both sexes.

Descriptive statistics of the measurements

The vast majority of the measurements follow mostly a normal distribution. Major exceptions can be found in the transverse process width or spinous process length measurements on cervical and lumbar levels, which show often two major peaks in frequency; see also Figures 11 to 14. The complete descriptive statistics of all measurements, separated by major time groups and sex, could be found in appendix 3.

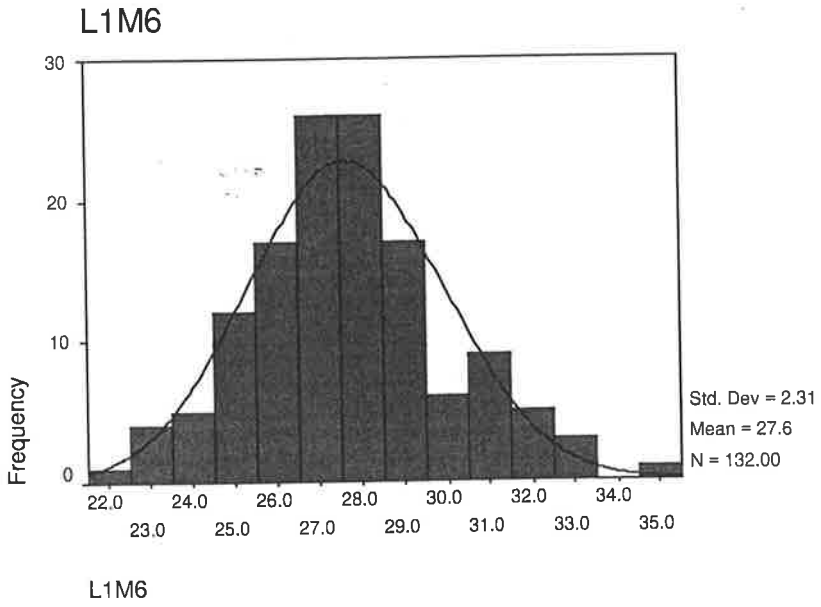


Figure 11: Sagittal diameter of L1 (L1M6) vertebral body in females showing mostly a normal distribution

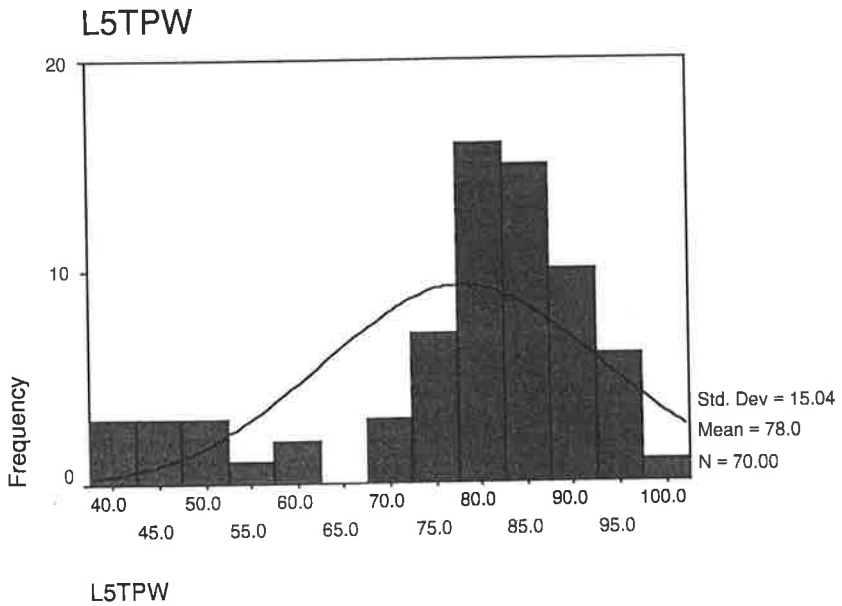


Figure 12: Transverse process width of L5 (L5TPW) in females showing a non-normal distribution

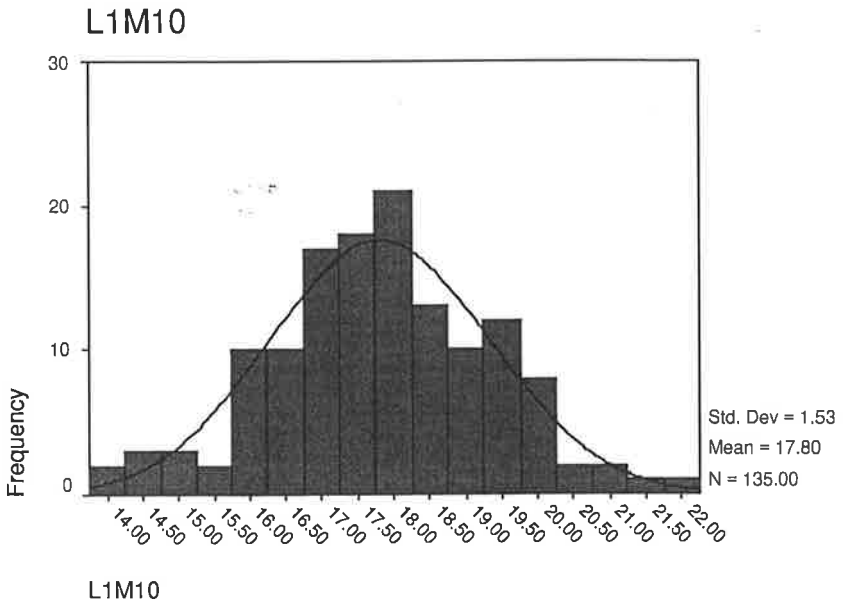


Figure 13: Transverse spinal canal diameters at L1 (L1M10) in males showing mostly a normal distribution

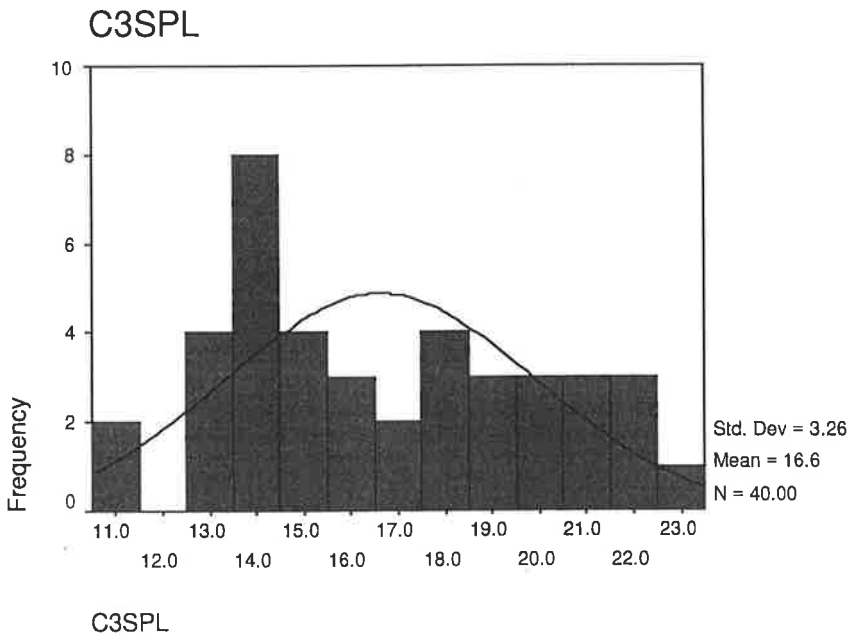


Figure 14: Spinous process lengths at C3 (C3SPL) in males showing a non-normal distribution

Osteometric data of the whole sample

The basic osteometric data, consisting of mean, standard deviation and number of measurements of a particular variable, are presented for both sexes separately in Table 7. Also listed in Table 7 are the same measures for the subgroup of "modern" individuals. Graphs of the examined spinal variables are shown, for the modern subgroups only, in Figure 15. The range curves, beside mean graphs for both sexes, are shown. Since usually females have smaller values than males, the female "mean minus standard deviation" is smaller than the same limits in males; therefore, just the female curve is shown. On the other hand, males will have higher values for the "mean plus standard deviation" - curve; therefore, their curve is shown as upper limit of range. As the only exception, in case of intervertebral foramen width the maximum range is defined by female "mean plus standard deviation" and males "mean minus standard deviation". The osteometric pattern for the modern samples is as follows:

The ventral vertebral body height shows generally a consistent increase from C3 caudally to the last lumbar levels in both sexes. The dorsal vertebral body height increases caudally from C3 to L1 and decreases for the last lumbar level in both in sexes.

For the sagittal vertebral body diameter, there is a consistent increase caudally in both sexes. The transverse vertebral body diameter also displays in general an increase caudally, again consistent in both sexes, but with the single exception of Th6, which shows slightly smaller values than Th1.

Pedicle heights follow a similar pattern on both sides and are bigger in males than in females. The pedicle heights show an increase caudally from C3 to L1, with a decrease caudally in size for the last lumbar level.

The diameters of the osseous spinal canal show a different pattern. In both sexes there is a decrease in sagittal spinal canal size from C3 caudally with a subsequent increase in the upper thoracic spine to level Th6. Level Th10 shows slightly smaller values than Th6 in males, but increased means in females. Another increase caudally in the lumbar spine can be demonstrated and, finally, there is a decrease for the last lumbar level. The transverse diameter shows, again consistent for both sexes, an increase from level C3 to C7, followed by a decrease caudally till Th6, with a steady increase caudally; consistent in both sexes.

The spinous process length shows consistent in both sexes increase caudally from C3 to Th1, with a subsequent decrease until Th6 and another increase caudally. The last lumbar level finally shows a smaller spinous process than L1.

The transverse process width shows for both sexes an increase caudally in the cervical region, with a decrease for the thoracic levels and another increase in the lumbar region.

The cranial intervertebral foramen widths are bigger than the caudal ones on the same vertebra. The cranial intervertebral widths show consistent in both sexes similar values for most regions, except for level L1, which shows by far the biggest means.

The caudal intervertebral foramen widths increase in size from C3 caudally till Th10, again similar for both sexes. Whereas in females, L1 shows bigger values than Th10, in males the means of the first lumbar level are equal or even smaller than the ones to be found at Th10. Both sexes show a decrease in size for the last lumbar level.

The foramen magnum demonstrates bigger values in males than in females, with the sagittal diameter being larger than the transverse one. All long bone dimensions, including bi-iliac width, are bigger in males than in females.

Table 7: Mean, standard deviation (SD) and number of individuals measured (N) of all variables for whole sample and modern subgroups

Variable	Males			Males (Modern)			Females			Females (Modern)		
	Mean (mm)	SD	N	Mean (mm)	SD	N	Mean (mm)	SD	N	Mean (mm)	SD	N
Agegroup: Adult (Agegroup1); Matur (2), Senil (3)	1.8	0.7	179				1.6	0.7	169			
C3 dorsal vertebral body height dorsal	14.0	1.2	130	14.6	1.3	38	12.4	1.1	129	12.8	1.3	26
C3 ventral vertebral body height	13.7	1.1	129	14.1	1.0	38	12.3	1.2	126	12.5	1.2	24
C3 vertebral body sagittal diameter	16.0	1.5	124	16.2	1.5	36	14.8	1.3	125	14.7	1.4	25
C3 vertebral body transverse diameter	19.3	2.0	122	19.3	1.8	37	18.5	2.2	124	18.1	2.3	25
C3 left pedicle heigh	7.0	1.0	121	7.3	1.1	35	6.1	0.9	125	6.2	0.9	27
C3 right pedicle height	6.9	0.9	120	7.3	1.0	33	6.1	0.8	125	6.3	1.0	26
C3 spinal canal sagittal diameter	15.3	1.5	111	15.9	1.4	34	14.9	1.3	102	15.4	1.4	24
C3 spinal canal transverse diameter	24.1	1.8	124	24.5	1.7	38	23.1	1.4	124	23.9	1.6	26
C3 spinous process lenght	18.8	3.2	40	16.9	2.8	11	13.7	2.7	46	16.0	3.8	9
C3 transverse process width	54.8	4.1	75	56.1	3.7	22	50.0	3.7	71	51.9	3.8	17
C3 left cranial intervertebral foramen width	8.5	1.1	123	8.8	0.8	37	8.4	1.2	122	8.7	1.1	26
C3 left caudal intervertebral foramina width	7.8	1.4	121	8.2	1.3	35	7.9	1.6	124	8.3	1.2	27
C3 right cranial intervertebral foramen width	8.3	1.0	123	8.5	0.8	34	8.4	1.2	124	8.6	1.0	26
C3 right caudal intervertebral foramen width	7.7	1.4	124	8.2	1.3	35	7.9	1.5	124	8.1	1.3	26
C7 dorsal vertebral body height	14.9	1.1	133	15.2	1.3	38	13.6	1.1	129	13.6	1.4	26
C7 ventral vertebral body height	13.9	1.3	132	13.7	1.4	37	12.9	1.1	129	12.8	1.4	25
C7 vertebral body sagittal diameter	17.1	1.5	133	17.7	1.7	36	15.6	1.4	128	16.0	1.5	26
C7 vertebral body transverse diameter	26.5	2.3	131	26.6	2.2	36	24.8	2.1	128	24.4	1.8	26
C7 left pedicle height	7.3	0.9	127	7.5	0.9	38	6.6	0.9	125	6.5	0.9	26
C7 right pedicle height	7.2	0.9	129	7.5	1.0	38	6.6	0.9	130	6.6	1.1	27
C7 sagittal diameter spinal canal	14.9	1.4	127	15.1	1.5	38	14.3	1.3	120	14.5	1.3	26
C7 transverse diameter spinal canal	25.2	2.1	135	26.1	1.7	38	24.4	1.9	123	25.7	1.7	27
C7 spinous porcess length	30.1	4.3	80	31.5	4.2	23	26.2	3.3	69	26.1	2.8	14
C7 transverse process width	66.2	13.7	35	66.2	17.0	7	54.6	17.3	33	52.9	19.9	6
C7 left cranial intervertebral foramen width	8.1	1.0	127	8.3	0.9	35	8.3	0.9	119	8.6	0.8	26
C7 left caudal intervertebral foramen width	9.8	1.4	126	10.1	1.5	38	9.6	1.3	116	10.0	1.3	26
C7 right cranial intervertebral foramen width	8.3	0.8	128	8.6	0.7	35	8.4	0.9	120	8.6	0.8	25
C7 right caudal intervertebral foramen width	9.8	1.3	128	10.1	1.2	37	9.5	1.2	115	9.8	1.1	24
TH1 dorsal vertebral body height	17.2	1.3	139	17.3	1.4	40	15.6	1.2	128	15.7	1.4	28
TH1 ventral vertebral body height	16.0	1.4	135	16.0	1.3	38	14.6	1.2	125	14.5	1.4	27
TH1 sagittal diameter vertebral body	17.3	1.6	128	17.8	1.9	34	15.8	1.4	121	16.0	1.6	27
TH1 transverse diameter vertebral body	28.5	2.8	135	28.9	2.7	38	26.2	2.4	125	26.1	2.0	28
TH1 left pedicle height	9.4	1.2	133	9.3	1.2	40	8.4	1.1	123	8.4	1.2	28
TH1 righ pedicle height	9.2	1.2	133	9.1	1.3	39	8.4	1.1	128	8.3	1.1	28
TH1 spinal canal sagittal diameter	15.4	1.2	126	15.8	1.2	38	14.9	1.2	115	15.3	1.2	28
TH1 spinal canal transverse diameter	22.4	2.0	130	23.3	1.8	40	21.3	1.8	122	22.2	1.7	28
TH1 spinous process lenght	31.7	4.1	81	33.2	3.5	20	27.5	3.4	54	29.1	2.9	13
TH1 transverse process width	78.0	6.1	106	79.1	5.0	35	70.9	5.0	90	72.5	3.8	25
TH1 left cranial intervertebral foramen width	8.4	1.0	128	8.6	1.0	38	8.4	0.9	117	8.6	1.0	28
TH1 left caudal intervertebral foramen width	10.3	1.5	129	10.9	1.5	39	10.2	1.4	115	10.3	1.3	27
TH1 right cranial intervertebral foramen width	8.3	0.9	121	8.5	0.9	35	8.4	0.9	120	8.7	0.9	28
TH1 right caudal intervertebral foramen width	10.2	1.3	125	10.6	1.4	39	10.1	1.4	116	10.4	1.5	27
TH6 dorsal vertebral body height	20.9	1.5	127	21.0	1.3	36	19.2	1.3	122	19.6	1.4	26
TH6 ventral vertebral body height	19.0	1.4	123	19.0	1.6	35	17.5	1.2	123	17.7	1.2	27
TH6 sagittal diameter vertebral body	25.8	2.3	119	26.3	2.4	34	22.9	2.2	121	23.6	2.3	27
TH6 transverse diameter vertebral body	27.8	2.1	124	27.9	2.2	36	24.8	1.7	125	24.6	1.9	28
TH6 left pedicle height	12.0	1.2	121	12.2	1.1	35	10.4	0.9	119	10.5	1.2	27
TH6 right pedicle height	12.2	1.3	124	12.6	1.0	36	10.5	0.9	120	10.8	1.2	27
TH6 spinal canal sagittal diameter	16.3	1.2	111	16.7	1.2	34	15.9	1.1	109	16.2	1.0	26
TH6 spinal canal transverse diameter	17.3	1.5	123	17.7	1.4	36	16.6	1.6	119	16.9	1.7	27
TH6 spinous process length	19.5	5.7	42	18.7	5.2	13	16.0	5.0	43	17.0	5.4	11
TH6 transverse process width	65.1	5.2	73	65.5	4.4	27	59.7	5.3	88	60.9	4.1	22
TH6 left caudal intervertebral foramen width	12.0	2.0	104	13.3	1.7	32	12.1	1.7	99	12.4	1.9	24
TH6 right caudal intervertebral foramen width	11.7	1.7	102	12.7	1.3	32	11.6	1.6	98	11.5	1.7	25
TH10 dorsal vertebral body height	23.7	1.8	138	23.8	1.4	38	21.7	1.8	135	22.1	1.4	28
TH10 ventral vertebral body height	22.2	1.5	133	22.2	1.5	34	20.9	1.6	132	21.4	1.7	28
TH10 vertebral body sagittal diameter	30.0	3.0	128	31.3	3.2	31	26.2	2.3	132	27.3	2.4	26
TH10 vertebral body transverse diameter	34.2	3.1	139	34.7	3.3	39	30.4	2.4	136	31.0	2.3	29
TH10 left pedicle height	15.5	1.4	136	15.7	1.4	40	13.8	1.4	131	14.3	1.7	28
TH10 right pedicle height	15.4	1.3	134	15.8	1.2	38	14.0	1.3	132	14.3	1.7	27
TH10 spinal canal sagittal diameter	16.2	1.4	131	16.4	1.6	38	15.7	1.5	124	16.4	1.3	27
TH10 spinal canal transverse diameter	18.4	1.7	137	18.8	1.8	40	17.3	1.5	129	17.9	1.7	28
TH10 spinous process lenght	26.6	4.5	54	30.4	3.6	11	24.1	3.8	57	26.1	4.0	13
TH10 transverse process width	60.7	5.5	84	63.0	4.8	24	55.0	5.3	91	56.1	4.6	22
TH10 left caudal intervertebral foramen width	12.4	1.9	128	13.1	1.8	38	12.2	1.5	119	12.7	1.1	28
TH10 right caudal intervertebral foramen width	12.1	1.9	128	12.9	1.9	37	11.9	1.5	120	12.6	1.1	27
L1 dorsal vertebral body height	26.0	1.8	153	27.9	1.6	36	24.3	1.8	141	25.4	2.0	27
L1 ventral vertebral body height	25.8	2.0	145	25.5	2.1	36	24.7	1.9	136	25.0	1.8	25
L1 vertebral body sagittal diameter	31.7	2.9	137	32.9	2.8	33	27.6	2.3	132	28.2	2.6	25
L1 vertebral body transverse diameter	40.3	3.2	151	41.0	3.3	37	35.5	3.0	138	35.9	2.8	28
L1 left pedicle height	15.7	1.3	146	16.4	1.3	35	14.3	1.2	137	14.4	1.3	27
L1 right pedicle height	16.0	1.4	147	16.5	1.6	36	14.5	1.4	142	14.8	1.5	28
L1 spinal canal sagittal diameter	17.8	1.5	135	18.2	1.7	34	17.7	1.5	126	18.4	1.5	28
L1 spinal canal transverse diameter	23.7	1.8	142	24.4	2.0	35	22.5	1.7	140	23.2	1.7	28
L1 spinous process lenght	30.1	4.2	55	32.3	5.7	8	26.4	3.9	57	29.2	3.8	13
L1 transverse process width	73.0	10.2	52	75.1	11.1	16	64.6	7.7	58	66.3	6.3	15
L1 left cranial intervertebral foramen width	8.2	1.2	137	8.6	1.3	34	8.6	1.2	121	9.1	1.3	28
L1 left caudal intervertebral foramen width	12.6	1.8	132	13.1	2.3	34	13.0	1.5	120	13.8	1.4	27
L1 right cranial intervertebral foramen width	8.4	1.1	131	8.9	1.3	32	8.9	1.2	115	9.5	1.3	27
L1 right caudal intervertebral foramina width	12.5	1.7	129	13.0	2.0	34	12.9	1.4	122	13.4	1.3	27
L5 dorsal vertebral body height	24.5	2.0	142	24.1	1.9	36	23.4	2.0	138	23.6	1.8	26
L5 ventral vertebral body height	28.6	2.4	143	28.9	2.3	37	27.0	2.6	132	28.1	2.0	24
L5 vertebral body sagittal diameter	33.6	3.1	137	34.5	3.1	32	31.1	2.7	131	30.4	2.6	23
L5 vertebral body transverse diameter	47.8	4.4	148	47.7	5.0	38	44.1	3.6	142	42.6	3.2	27
L5 left pedicle height	14.0	1.8	144	13.9	1.6	38	12.8	1.9	132	12.7	2.2	26
L5 right pedicle height	14.8	2.0	140	14.5	1.8	37	13.5	1.8	134	13.3	2.1	26
L5 spinal canal sagittal diameter	16.9	2.1	124	17.7	2.3	35	16.9	2.2	118	17.7	1.9	25
L5 spinal canal transverse diameter	26.2	2.5	136	26.3	3.0	38	25.0	2.7	130	26.5	2.9	27
L5 spinous processus lenght	26.3	4.1	57	29.9	3.7	11	24.2	3.8	60	26.7	3.9	13
L5 transverse process width	85.2	16.5	60	91.5	7.4	18	78.0	14.9	70	84.5	10.2	15
L5 left cranial intervertebral foramen width	8.0	1.0	139	8.5	1.0	38	8.4	1.0	132	8.9	1.1	27
L5 left caudal intervertebral foramen width	9.9	1.9	129	10.1	2.2	37	10.5	1.8	127	11.3	1.6	27
L5 right cranial intervertebral foramen width	8.1	0.9	133	8.3	0.9	35	8.5	1.1	128	7.1	1.3	27
L5 right caudal intervertebral foramen width	9.8	1.7	125	9.8	1.7	36	10.5	1.8	126	11.3	1.6	27
foramen magnum sagittal diameter	37.2	2.6	59	37.3	2.5	28	35.8	2.8	52	35.8	3.4	21
foramen magnum transverse diameter	32.1	2.4	58	32.4	2.2	28	30.0	2.6	52	31.0	2.7	21
humerus lenght	326.8	18.1	134	325.5	14.3	36	299.9	19.6	124	304.3	20.8	29
humerus circumference	65.5	4.9	163	67.3	5.5	40	57.2	4.1	151	58.7	4.9	30
femoral head width	48.3	3.4	160	49.4	3.1	39	42.6	2.7	159	43.9	3.1	29
femur lenght	455.4	27.3	136	453.4	24.9	36	422.6	25.7	132	426.5	24.8	26
femur circumference	89.4	6.8	162	89.4	6.8	39	79.7	5.8	154	82.7	6.0	29
bi-iliac width	282.9	16.9	68	289.8	16.3	24	271.8	17.3	79	282.2	15.4	25

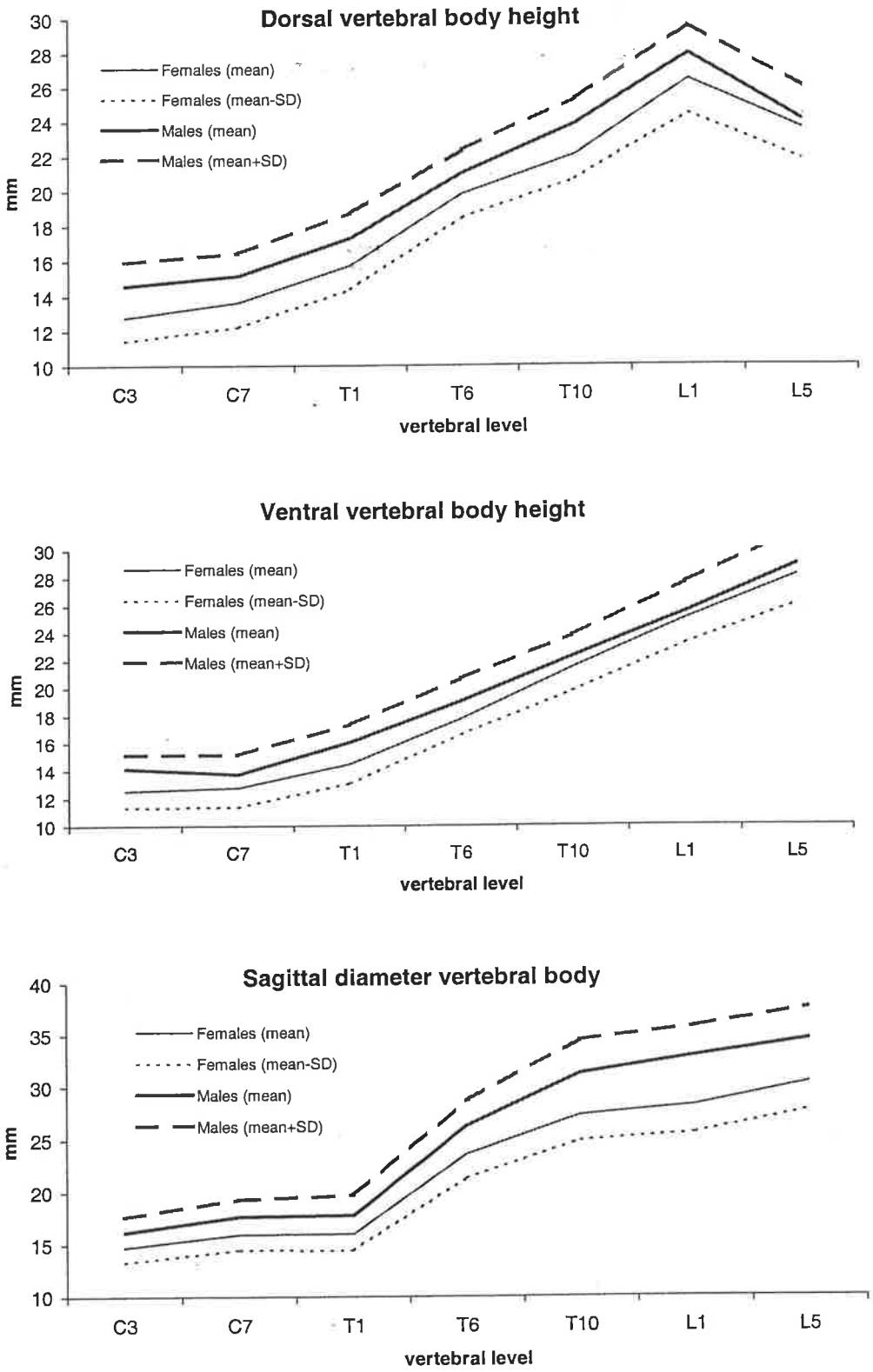
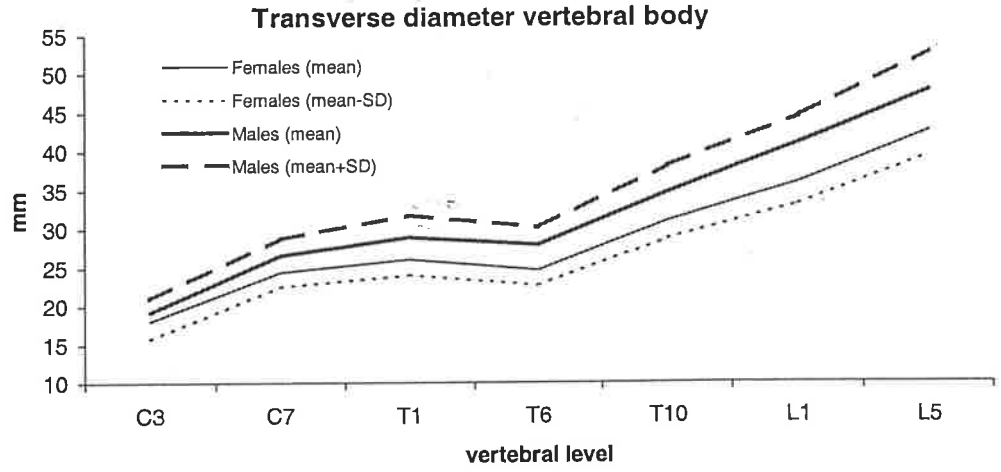
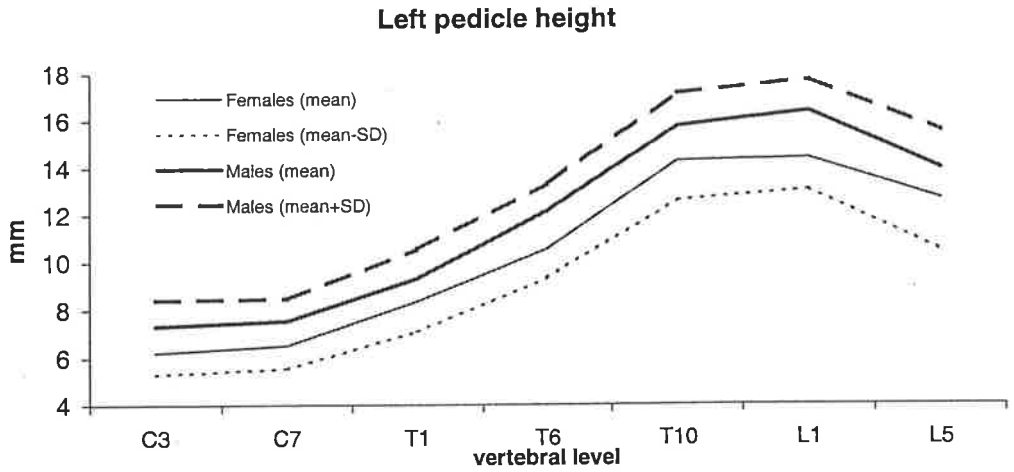


Figure 15: Variables by vertebral levels with mean for males and females and maximum one standard deviation range (male mean+SD, female mean-SD)





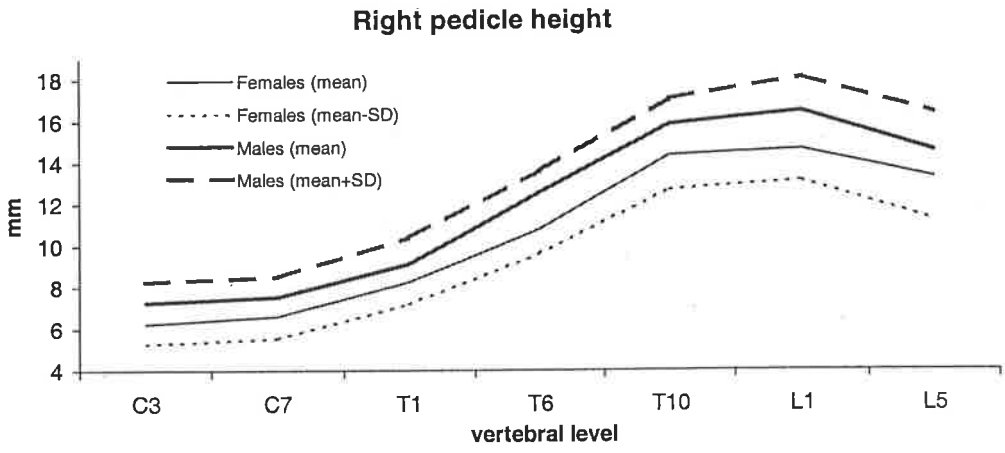
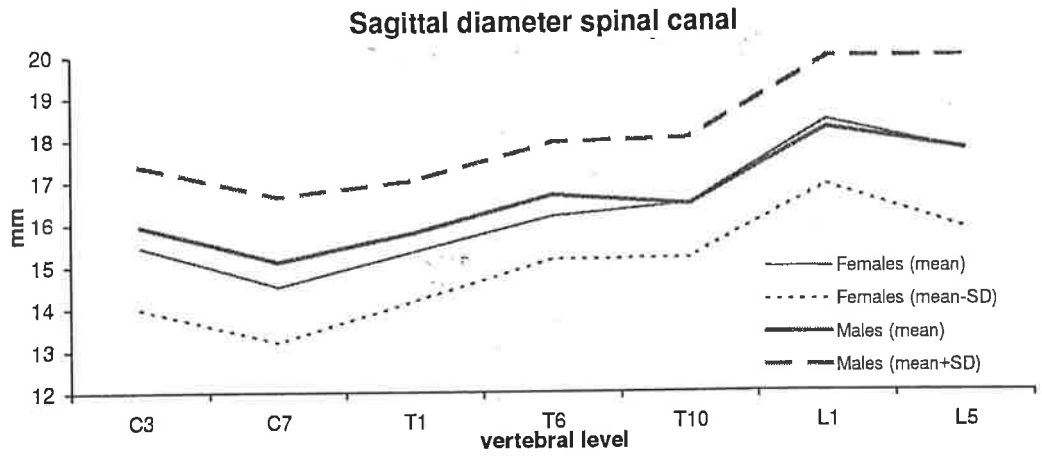
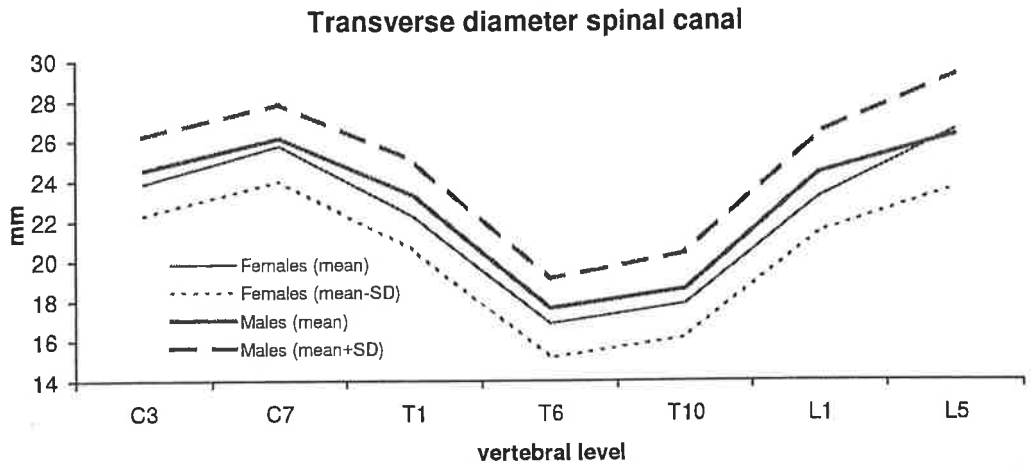


Figure 15 (cont.): Variables by vertebral levels with mean for males and females and maximum one standard deviation range (male mean+SD, female mean-SD)





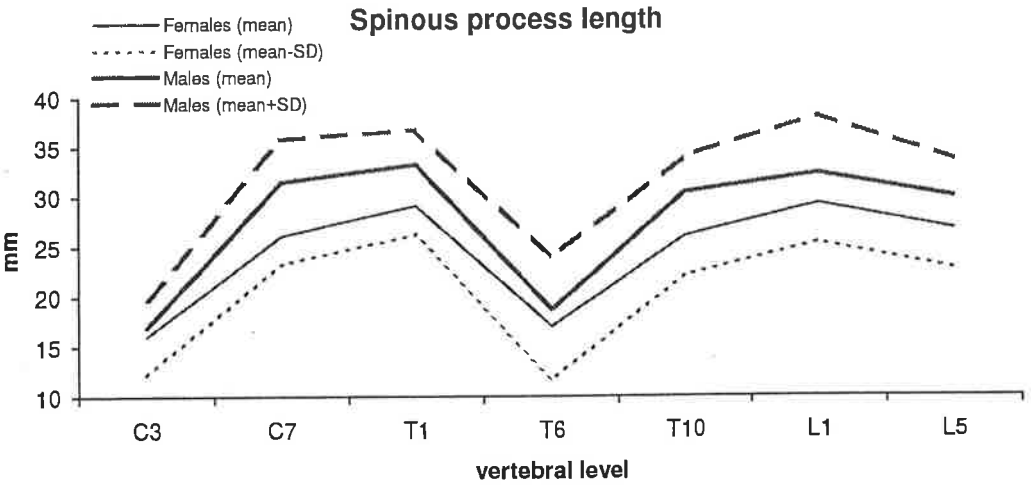
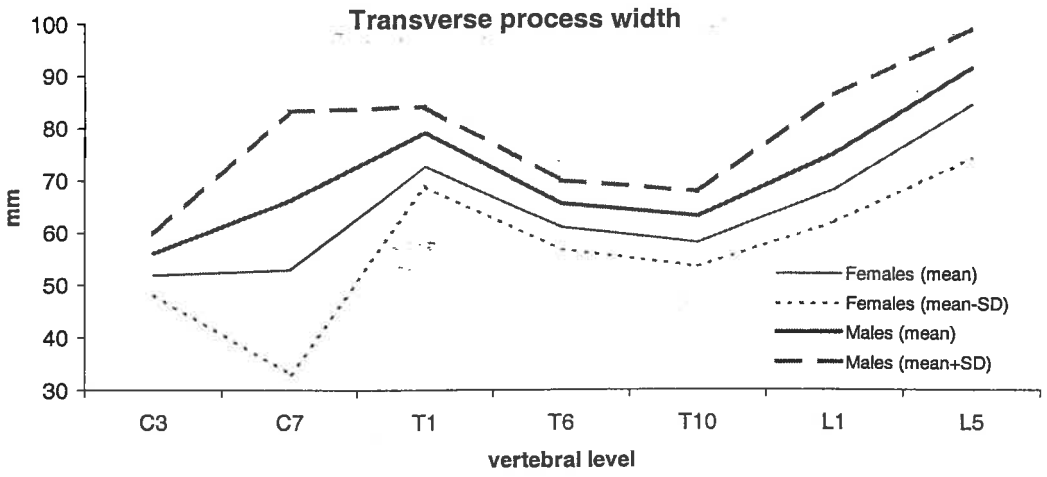
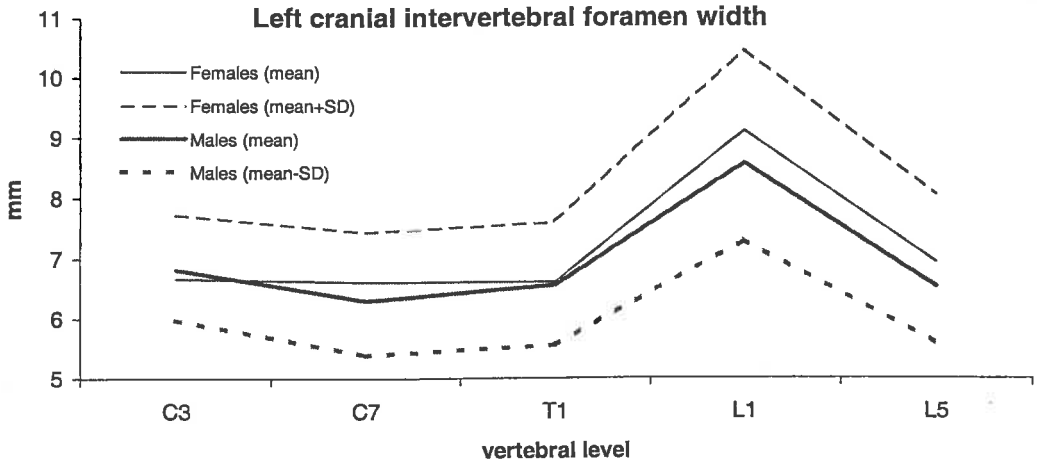


Figure 15 (cont.): Variables by vertebral levels with mean for males and females and maximum one standard deviation range (male mean+SD, female mean-SD)





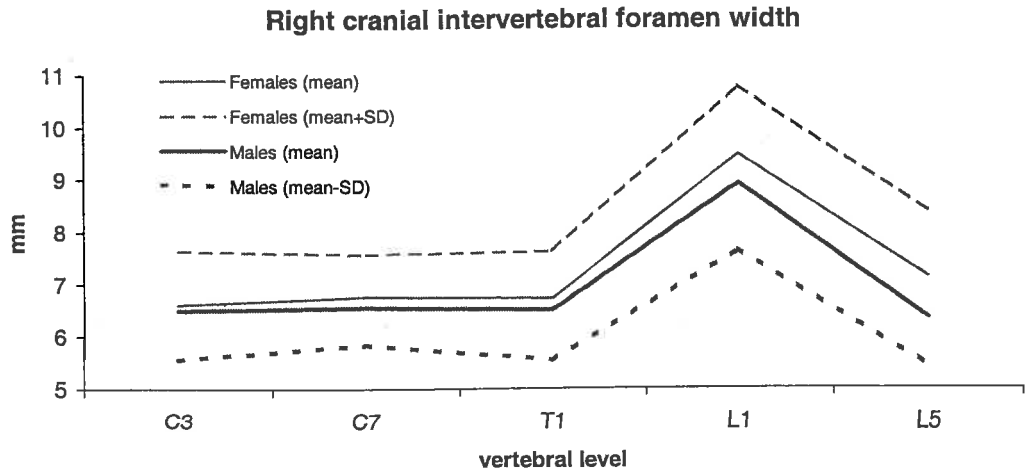
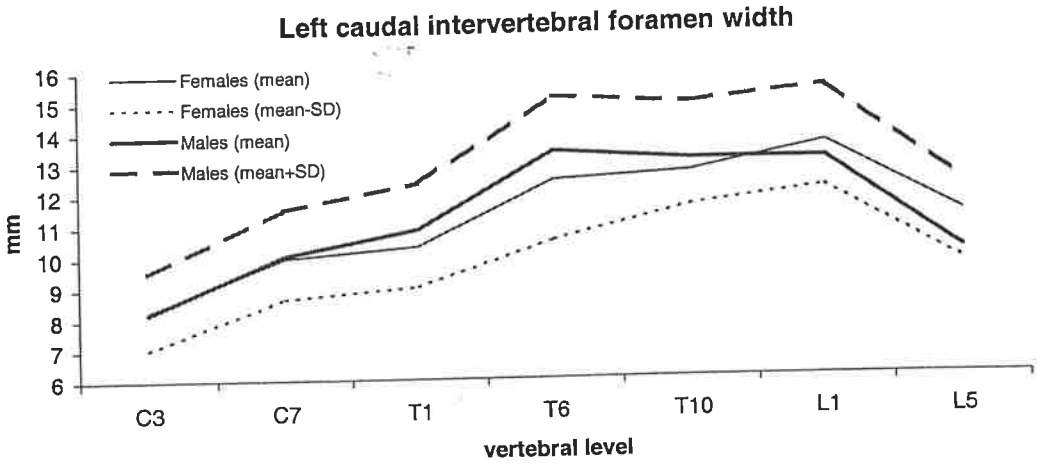


Figure 15 (cont.): Variables by vertebral levels with mean for males and females and maximum one standard deviation range (maximum range is defined by female mean+SD, male mean-SD)



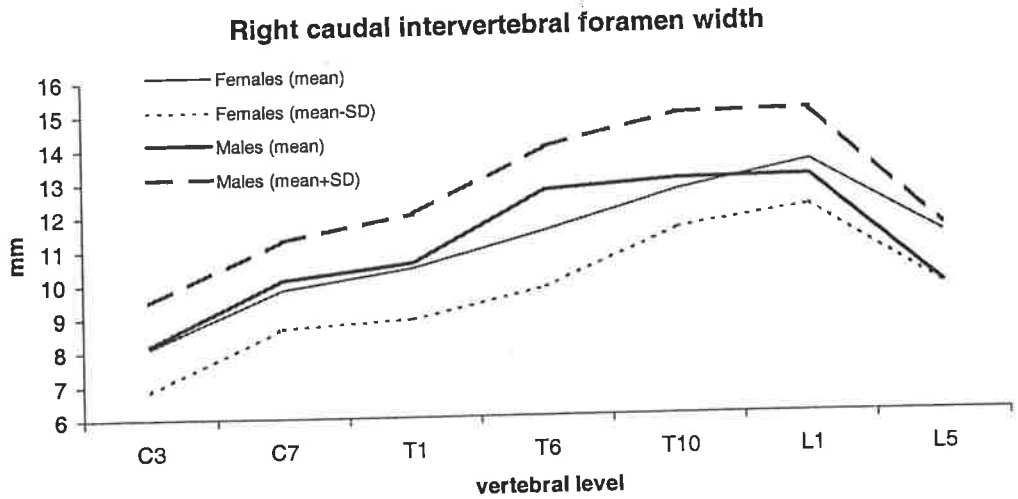


Figure 15 (cont.): Variables by vertebral levels with mean for males and females and maximum one standard deviation range (male mean+SD, female mean-SD)

Sexual dimorphism

As already mentioned above, for the vast majority of the explored variables of the whole sample, males show bigger values than females.

Female mean values were compared as percentages of male ones, with the latter ones assumed as being 100%. Femur length was on average 7% bigger in males, while femur circumference was approximately 11% different. Similar sexual dimorphism pattern can be found for the two variables of the humerus. Furthermore, femoral head breadth shows a sex difference of almost 12%. Females present in relation to femur length a larger bi-iliac width, which is on average just 4% smaller than in males.

Females have absolutely bigger values for a large number of intervertebral foramen widths. These are the only variables examined, of which some are absolutely larger in females than males. Values absolutely bigger in males, but relative to percentage difference of femur length *de facto* larger in females, are additional intervertebral foramina and a lot of the neural canal measurements, especially the sagittal dimensions.

In relation to femur length differences, larger values can be found in males, especially for most of the spinous process lengths, as well as frequently for the pedicle heights. Furthermore, some values of sagittal and transverse vertebral body dimensions are also, relative to femur length sex differences, bigger in males. The foramen magnum dimensions are larger in males than in females, but the sexual dimorphism is for both diameters smaller than the average femur length sex-difference.

Significant sex differences in mean values, after application of Bonferroni's correction, were found among the modern samples with proven individuals' sex. For

most vertebral body dimensions such as height and diameters, for most transverse process widths as well as for pedicle height, there is a significant sexual dimorphism with males showing larger dimensions; whereas for the vast majority of the spinal canal diameters and intervertebral foramen widths, there is no significant difference in mean value between sexes. A complete list of all percentage- and t-values of sexual dimorphism could be found in appendix 4.

Side differences of spinal measurements

Possible side difference was tested for the mean values of the bilaterally measured spinal dimensions, which are pedicle height and intervertebral foramen widths, in the modern samples. No significant side differences, for both males and females, have been found for these measures. The t-values, which are non-significant for any measurement at level $p<0.05$, even before the application of Bonferroni's correction for multiple comparisons, could be found in appendix 5.

Inter-correlations of all measurements

The correlations of the osteometric variables with each other show consistent patterns, which are similar in both sexes. The complete list of all inter-correlations could be found in appendix 9.

In general, comparable measurements of anatomically closer located vertebral levels tend to correlate to a higher degree with each other than the same ones located further apart. Additionally, even unrelated measurements, but still closely located in terms of neighbouring vertebral levels, correlate significantly with each other. Furthermore, similar measurements even in largely far apart locations correlate well

with each other. There is also a high correlation between the same measurements on both right and left side, as performed here in the cases of the pedicle heights and the intervertebral foramen widths. Typical examples of high vertebral inter-correlations, with a Pearson correlation coefficient of usually at least approximately 0.6, are ventral *versus* dorsal vertebral body height, sagittal *versus* transverse vertebral body dimensions or transverse *versus* sagittal spinal canal diameters, as measured on the same vertebral level.

The foramen magnum shows primarily significant correlations between its sagittal dimension and the examined sagittal dimensions of the spinal canal. The long bone measurements demonstrate mostly high correlations with each other. Both, femur and humerus show a large number of medium level correlations, but still significant, with various vertebral measurements. The bi-iliac width shows fewer correlations than other non-vertebral measurements with the vertebral dimensions, but still it expresses a few mild ones, especially with the sagittal vertebral body dimension and the transverse spinal canal dimensions.

Correlation of examined variables with individual age

The correlation of individual age with the selected spinal and long bone measurements has been tested on the two modern samples; see also Figure 16.

In males, after application of Bonferroni's correction, multiple variables show significant alterations in relation to individual age. At most levels, the sagittal diameter of the vertebral bodies and its transverse diameter show an increase with individual age. Additionally, the pedicle height shows an increase in size with age. This effect is more clearly visible on the right side than on the left, in the latter one the significance

vanishes on more levels after the application of Bonferroni's correction. Additional single variables increasing significantly with age are the transverse process width on Th1 and the left cranial intervertebral foramen width on L5. Furthermore, humerus minimal circumference and mid-femur circumference increase significantly with age in males. Only significant before the application of Bonferroni's correction were transverse process width on two levels as well as dorsal vertebral body height and transverse spinal canal dimension on C3 and the sagittal vertebral body diameter on Th10. Not a single variable decreases significantly with age in males.

If one applies in males this analysis to the skeletal samples without any proven sexing and individual aging, which, basically, are all "pre-modern" time groups, a similar tendency can be found. Most of the variables, which were found to correlate with individual age in the modern samples, follow a similar pattern in the "pre-modern" samples. Beside all long bone measurements, the sagittal and transverse diameters of the vertebral bodies increase with age in these individuals. All skeletons have been assessed for this particular analysis using only the three major age groups.

In females just femur length showed a significant decrease with age; see also Figure 16. No other long bone or spinal measurement revealed, after Bonferroni's correction, a significant alteration with individual age. Without application of Bonferroni's correction, a significant decrease in transverse process width on C3 and of ventral vertebral body height on L5, as well as an increase in sagittal dimension of the spinal canal and right maximum pedicle height on C7, can be found.

Again, if one applies this analysis to the skeletal samples without any proven sexing and individual aging, for females a different pattern emerges. The sagittal

dimensions of the vertebral bodies of the cranial half of the spine and femur circumference increase then with individual age.

Selected scattergrams of spinal and long bone measurements, significantly changing with individual age, are presented in Figure 16. The complete data set on correlation between the osteometric measurements and individual age at death or major age groups, respectively, could be found in the appendices 6 – 8.

If one divides the sample not only in the two sexes but also additionally into the three major time groups and then analyses the correlation between the measurements and individual age group, the trends found become weaker and less consistent, even within the same sex.

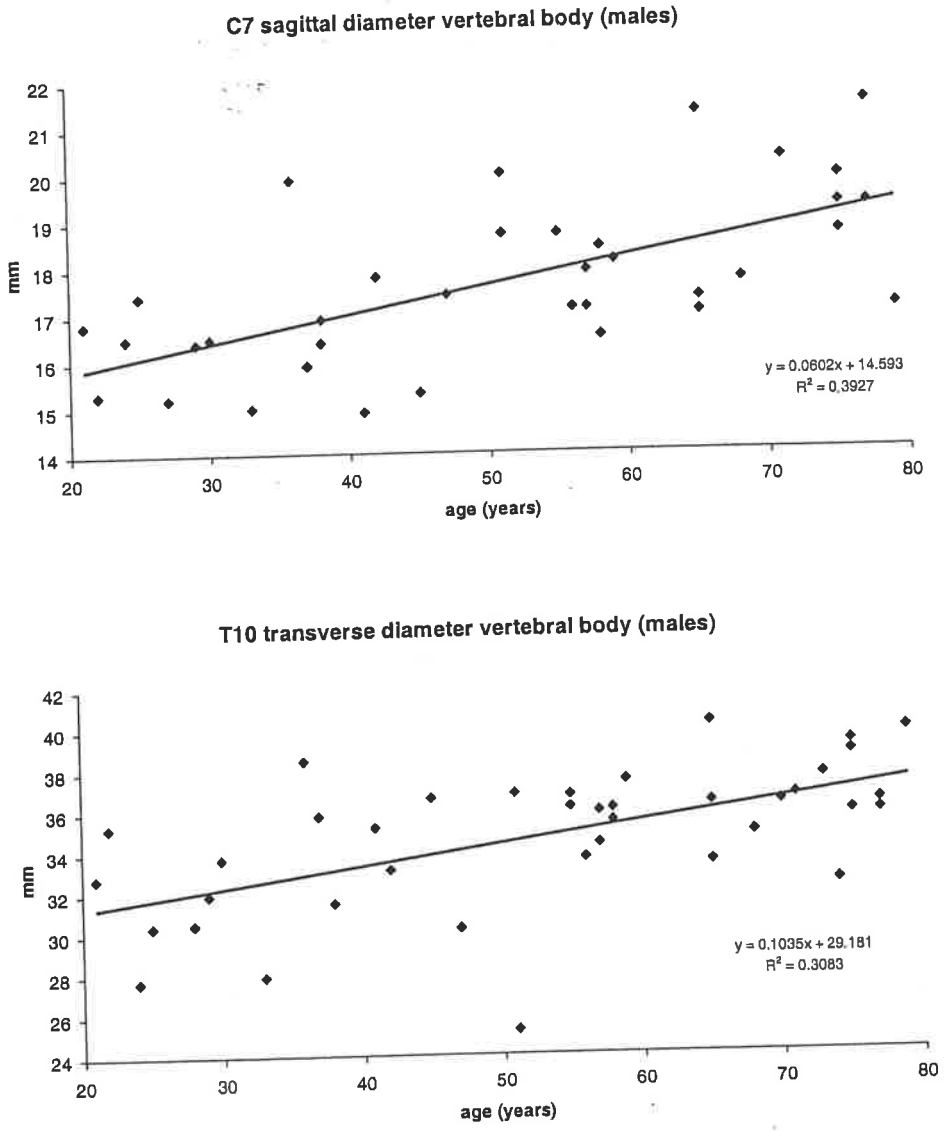
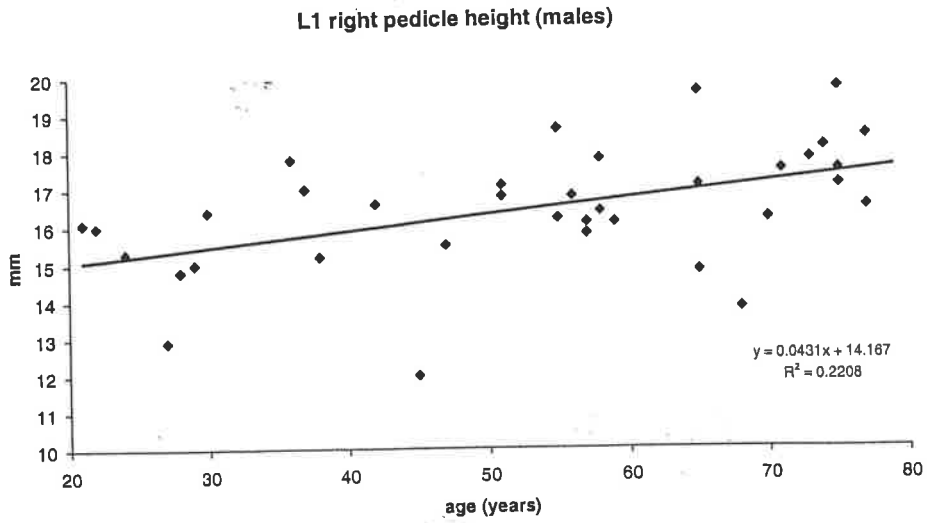


Figure 16: Selected variables with significant change with known individual age in modern samples



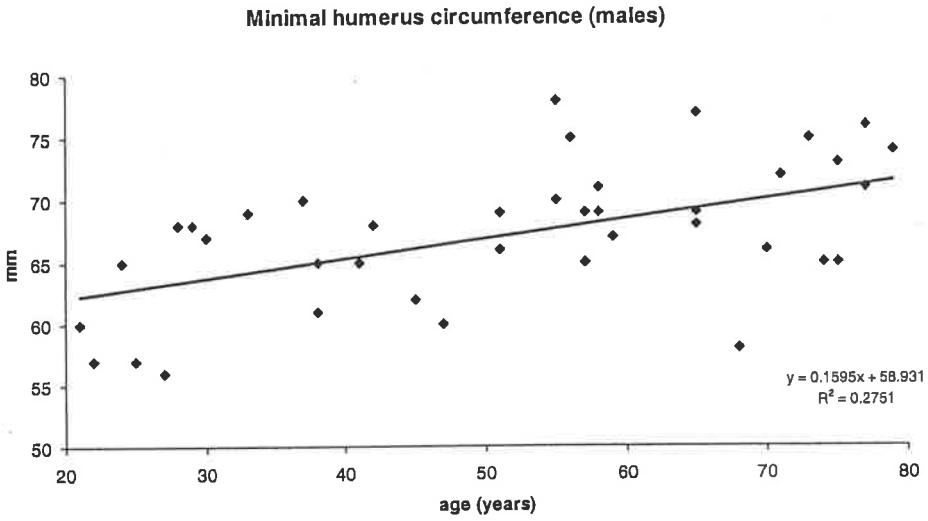
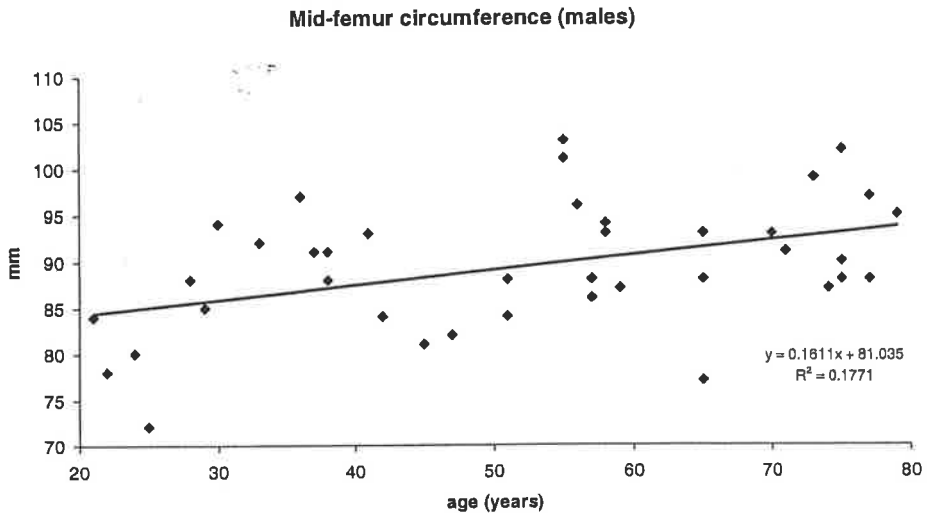


Figure 16 (cont.): Selected variables with significant change with known individual age in modern samples



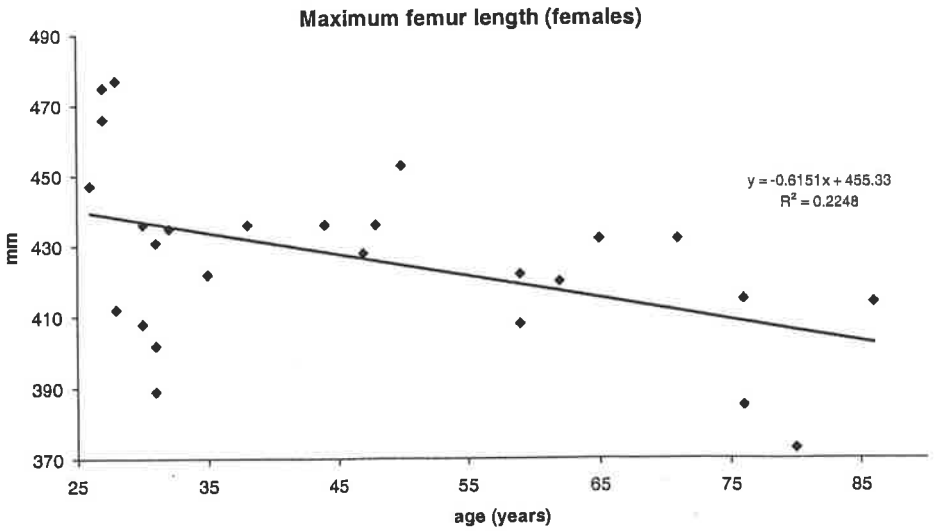


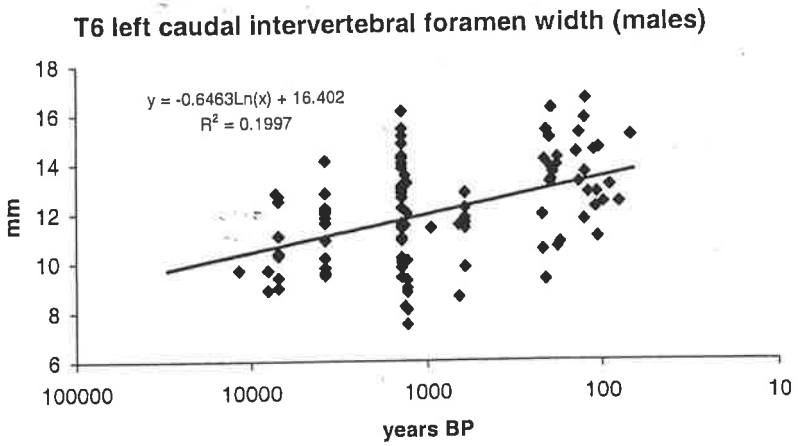
Figure 16 (cont.): Selected variables with significant change with known individual age in modern samples

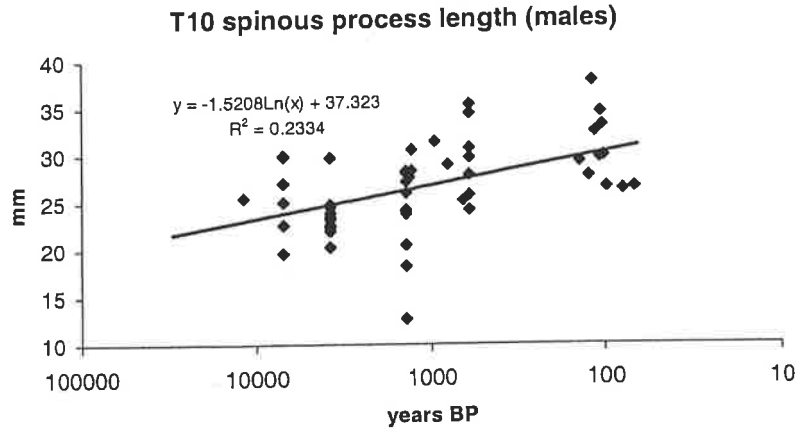
Microevolutionary trends since the Late Pleistocene

All samples, including the single individuals from the Paleolithic and Mesolithic, were included to test for significant microevolutionary trends in spinal and long bone osteometry. The regression models with the highest significance, after application of Bonferroni's correction for multiple comparisons, for each of the examined variables are listed sex-matched in appendix 10. Selected scattergrams of significant trends are shown in Figures 17 and 18.

In males, with the single exception of the transverse diameter of the vertebral body at level C3, all other significant microevolutionary changes of the examined variables show an increase since the Late Pleistocene. Most significant alterations are of logarithmic shape. All measurements show for at least one level a microevolutionary change, most of them for several levels. The foramen magnum dimensions do not show a significant microevolutionary change. All long bone measurements, the bi-iliac width and the age groups express a significant temporal increase as well.

In females, most of the significant microevolutionary alterations are of positive nature as well. Only a few such as e.g., femur length or several intervertebral foramen widths, decrease through time. The vast majority of the variables show an increase since the Late Pleistocene. Most of the variables, which show a significant microevolutionary alteration, follow a logarithmic pattern. Some of the non-spinal measurements, such as humerus length or bi-iliac width, increase through time in females as well. Again, as in males, the foramen magnum does not show a significant alteration. Finally, the age groups show also a positive microevolutionary trend.





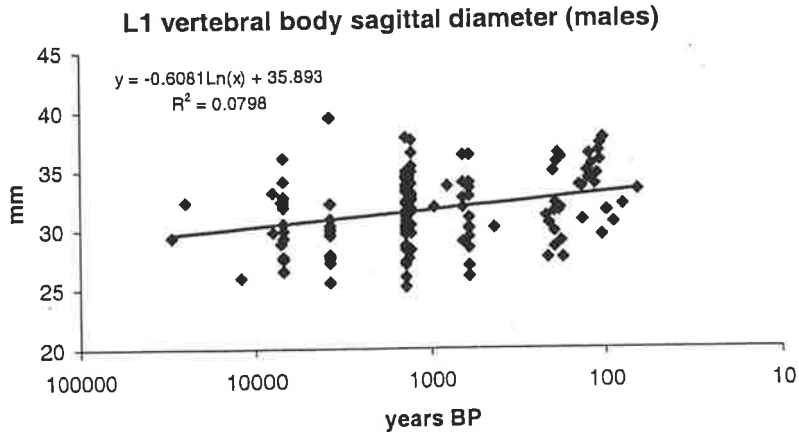
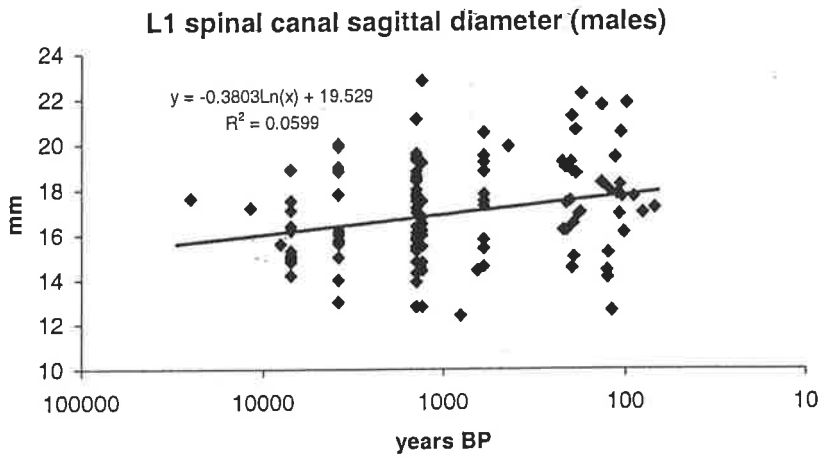
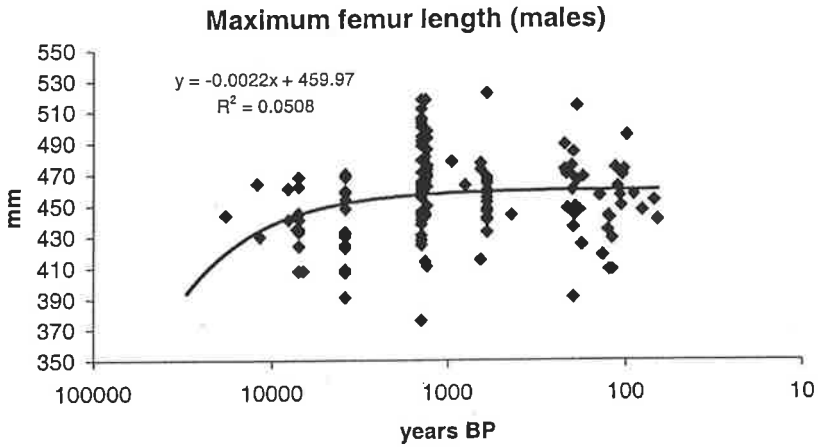


Figure 17: Selected variables with significant microevolutionary trends in males





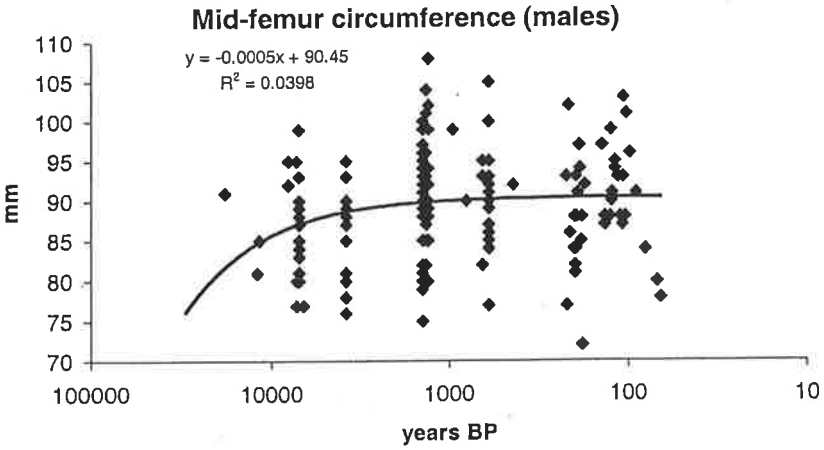


Figure 17 (cont.): Selected variables with significant microevolutionary trends in males

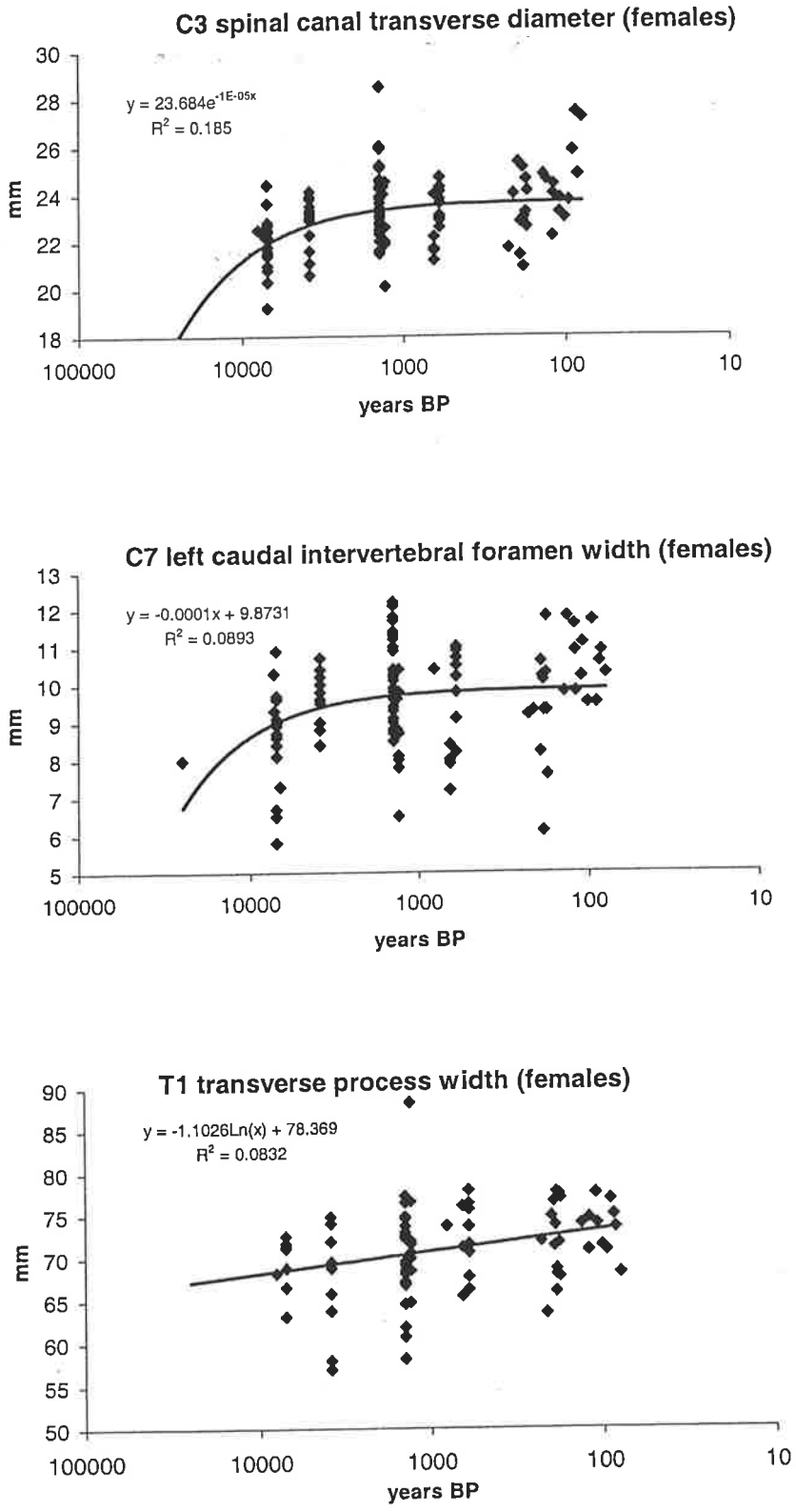
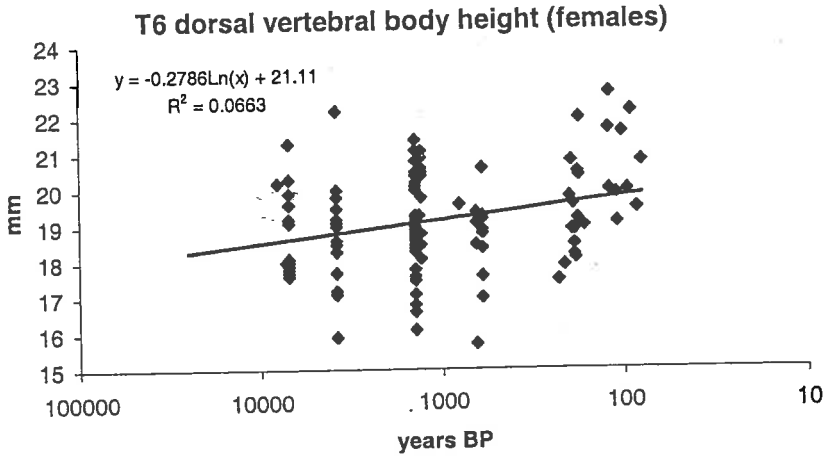
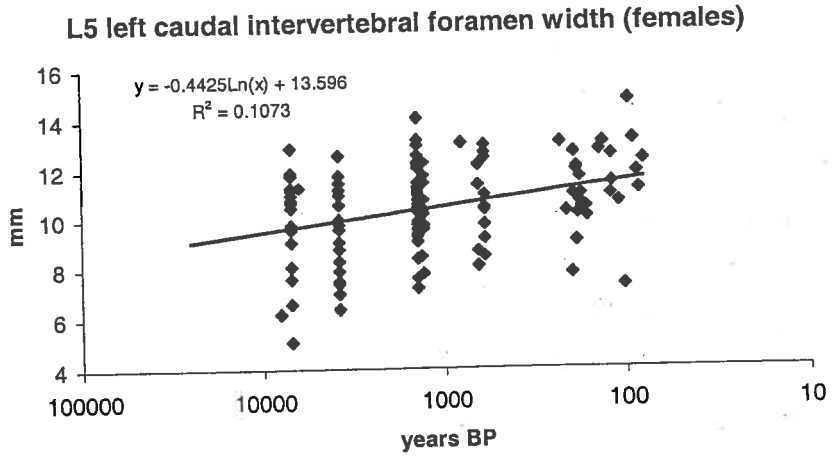


Figure 18: Selected variables with significant microevolutionary trends in females





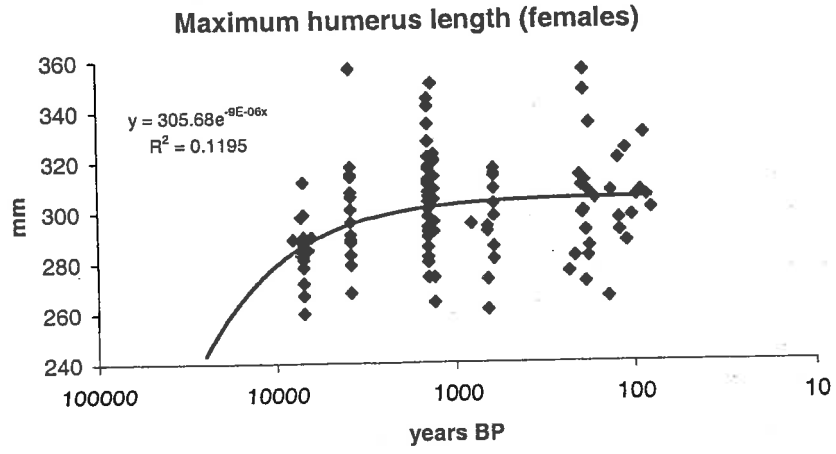


Figure 18 (cont.): Selected variables with significant microevolutionary trends in females

Secular changes of the intervertebral foramen in the modern samples

The intervertebral foramen was further assessed by linear regression in the modern samples; see also Tables 8 and 9.

A positive secular trend of the slopes for nearly all selected levels of the maximum intervertebral foramen width, with females demonstrating mostly a stronger tendency, can be found. For females, on C3, left side only (r=0.77) and bilateral on L1 (r_{right}=0.60, r_{left}=0.61), the increase was significant, even after application of Bonferroni's correction for multiple comparisons. Other positive secular slope trends, significant only before application of Bonferroni's correction, were found in females on C7 bilateral (r_{right}=0.48, r_{left}=0.45), Th1 bilateral (r_{right}=0.39, r_{left}=0.52), Th6 right (r=0.46) and in males on C7 right (r=0.37), Th1 bilateral (r_{right}=0.46, r_{left}=0.33) and L5 left (r=0.42).

Intervertebral foramen height, as calculated by subtracting pedicle height from posterior vertebral body height, showed mostly a mild negative secular trend in either sex, only significant before Bonferroni's correction, in females for C7 bilateral (r_{right}=-0.40, r_{left}=-0.42) and in males for C7 on the right side only (r=-0.35). Intervertebral foramen heights on Th10 in females and Th10, L1 and L5, all on both sides, in males were the only ones demonstrating a positive, still insignificant, secular trend.

Table 8: Pearson correlation coefficients (r) of caudal intervertebral foramen width with birth year in modern samples (N total=71, significant at $p<0.05$ before* and after** application of Bonferroni's correction for multiple comparisons)

Level / side	r – Females	r - Males
C3 / left	0.77**	0.24
C3 / right	0.54*	0.19
C7 / left	0.45*	0.09
C7 / right	0.48*	0.37*
Th1 / left	0.52*	0.33*
Th1 / right	0.39*	0.46*
Th6 / left	0.06	0.12
Th6 / right	0.46*	-0.03
Th10 / left	0.27	0.24
Th10 / right	0.35	0.19
L1 / left	0.61**	0.01
L1 / right	0.60**	0.16
L5 / left	0.24	0.42*
L5 / right	0.21	0.20

Table 9: Pearson correlation coefficients (r) of intervertebral foramen height with birth year (N total=71, significant at $p<0.05$ before* and after** application of Bonferroni's correction for multiple comparisons)

Level / side	r - Females	r - Males
C3 / left	-0.25	-0.15
C3 / right	-0.07	-0.13
C7 / left	-0.42*	-0.30
C7 / right	-0.40*	-0.35*
Th1 / left	-0.12	-0.07
Th1 / right	-0.14	-0.08
Th6 / left	-0.29	-0.01
Th6 / right	-0.36	-0.06
Th10 / left	0.19	0.05
Th10 / right	0.29	0.03
L1 / left	-0.16	0.31
L1 / right	-0.17	0.29
L5 / left	-0.20	0.02
L5 / right	-0.03	0.14

Analysis of variance: variable means with respect to time before present

An analysis of variance (ANOVA) was performed to test for significant influence of historical age. The various dates before present of the samples and individuals were divided into the three major time groups, with the Paleolithic and Mesolithic individuals neglected. Additionally, the ratios of sagittal divided by transverse vertebral body, foramen magnum or spinal canal diameters, as well as the robusticity indices of the long bones, were analysed too. A further subdivision of the samples, not only according to supposed sex but also within one of the main age groups, and then the application of an ANOVA, with applying Bonferroni's correction, expresses much less significant alterations and has not been further explored.

A complete data set of these examinations for both sexes can be found in appendix 11. A summarising graph showing the ANOVA results for means in graphic form could be seen in Figure 19, with borderline alterations being the ones, which are only significant before the application of Bonferroni's correction.

In males, the ANOVA shows, after Bonferroni's correction for multiple comparisons, a significant increase at most vertebral levels for the transverse width of the spinal canal. Furthermore, some levels of sagittal vertebral body diameters and caudal intervertebral foramen width show an increase as well. Additionally, all long bone measurements, foramen magnum length and bi-iliac width show a positive correlation. A significant negative alteration can be found only for the transverse diameter of the vertebral body at level C3. Of the calculated ratios, the majority of the vertebral body ratios and the humerus robusticity index show a significant positive change. Only significant before the application of Bonferroni's correction are some

levels of pedicle height, additional intervertebral foramen widths and especially selected levels of sagittal spinal canal and vertebral body diameters.

Furthermore, ANOVA was separately applied for the alterations between the three major time groups, Bronze Age / Neolithic, Medieval and modern times, respectively. As expected, some pairs of time groups show significant differences, but since the other pairs of the same variables do not, the overall change in means for this particular variable will not show a significant alteration with time at all, or it will just express one before the application of Bonferroni's correction. For example, there is a significant difference in age group mean between time group 1 and time group 3, but overall there is no such significant difference in males by applying ANOVA for this particular variable. The majority of the pairs showing significant differences in means are the Neolithic / Bronze Age time group 1 *versus* the modern time group 3. On the other hand, there are variables such as in males e.g., the dorsal height of the vertebral body at level C3 or sagittal diameter of the vertebral body at level Th6, which reveal differences between other pairs of time groups or between all of the time groups. In general, the least frequent significant differences can be found between time group 2 and 3, with the majority of such alterations to be visible between time groups 1 and 3. In males, both humerus measurements and femoral head breadth show significant differences between all time groups, whereas for the male femur variable, this is different. Only time group 1 and 2, which are the Neolithic / Bronze Age *versus* the Medieval samples, have significantly different femoral values. Furthermore, bi-iliac width in males does only express significant mean differences between time group 1 and time group 3.

In females, similar patterns emerge. The ANOVA shows, after application of Bonferroni's correction for multiple comparisons, significant difference in terms of time group for most of the transverse diameters of the spinal canal, as well as some of the intervertebral foramen widths. All these trends are of positive nature. Two levels of sagittal vertebral body diameters, Th6 and Th10, also show significant differences in females. Some vertebral variables, such as e.g., additional intervertebral foramen widths, or additional single diameters of the vertebral body or spinal canal, are only significant before the application of Bonferroni's correction. Two levels of transverse diameters of the vertebral body, C3 and L5, show a decrease in size, only significant before the application of Bonferroni's correction. None of the two foramen magnum dimensions expresses a significant alteration. With the exception of minimal humerus circumference, all other non-spinal variables express a significant positive alteration in females. The calculated spinal ratios and indices show just one with a positive significant trend, Th6 vertebral body dimensions, but also positive significant trends were found for both humeral and femoral robusticity. The foramen magnum dimension index shows a significant decrease in females. Some more ratios in females show significant alterations, only before the application of Bonferroni's correction. The further investigation of mean female variables, with respect to major time group pair differences, shows similar trends to males. Again, there are mean differences between single pairs of the major time groups, which disappear to be significant once all three major time groups are combined. In addition, most often significant differences can be found between time groups 1 and 3. Furthermore, the majority of the long bone measurements show significant differences between time groups 1 and 2, and 1 and 3, but not 2 and 3, respectively.

By comparing the trends in alteration of variable means between sexes, one finds that most of these significant trends are consistent for both sexes. This is in particular true for some intervertebral foramen widths, selected levels of spinal canal transverse diameters and sagittal diameters of vertebral bodies. Some trends are only significant in one sex after Bonferroni's correction, but would be significant, without Bonferroni's adjustment, in the other sex too. More often trends are significant in males only but not in females, than the opposite. All trends are consistent in their positive or negative nature between the two sexes, except for some of calculated ratios.

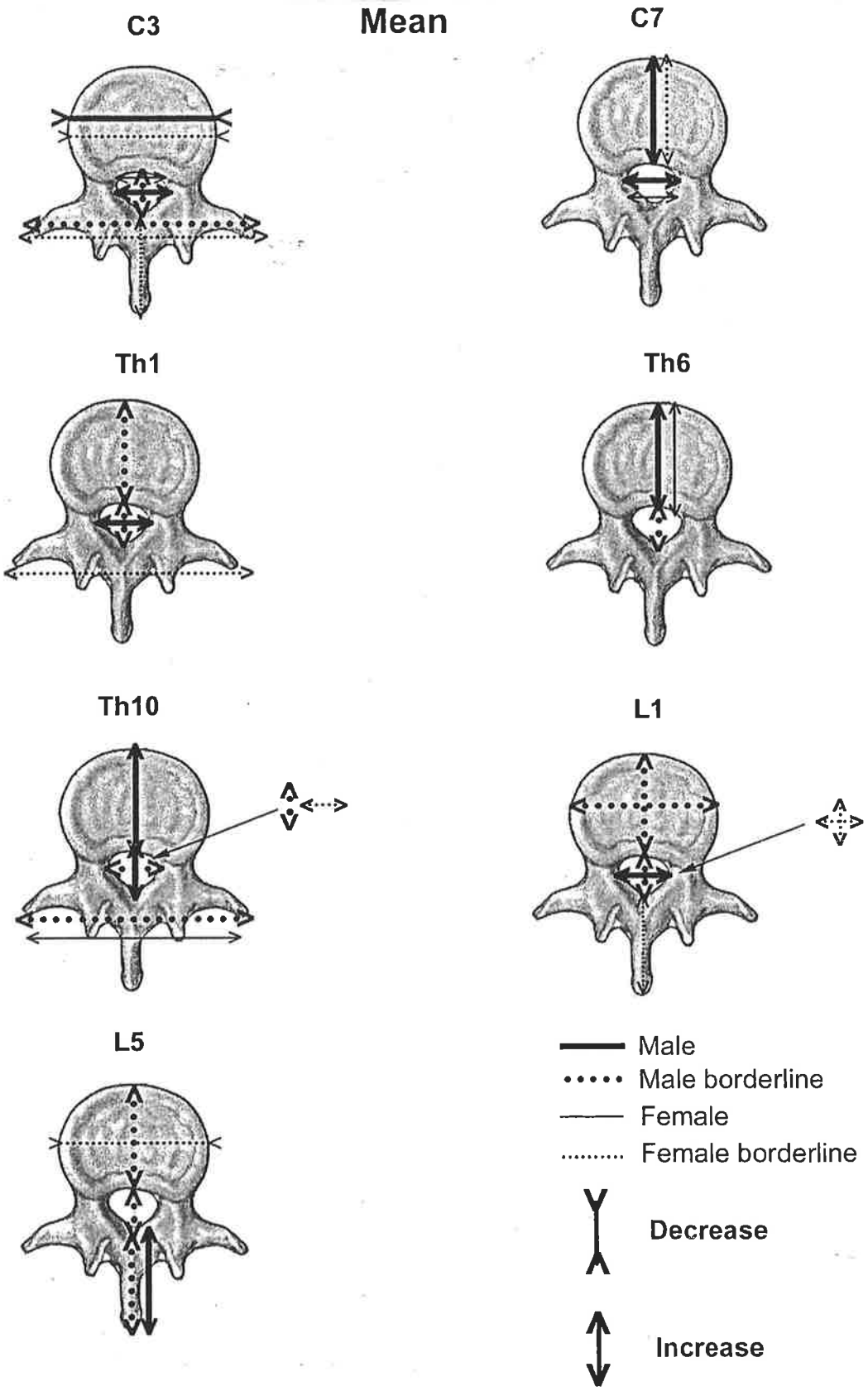


Figure 19: Significant and borderline alterations of mean values between Neolithic / Bronze Age and modern samples

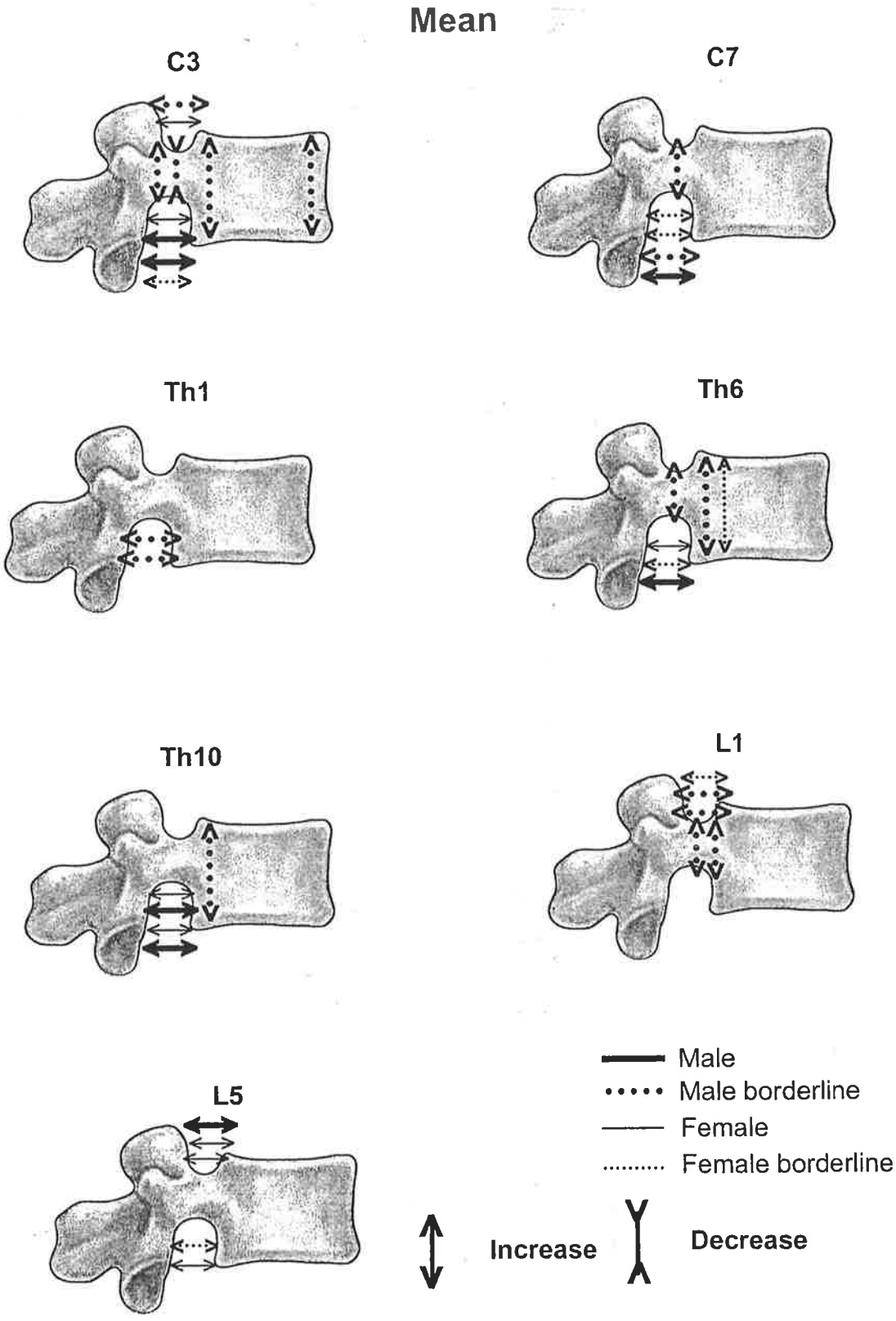


Figure 19 (cont.): Significant and borderline alterations of mean values between Neolithic / Bronze Age and modern samples

Analysis of variance: variable standard deviations with respect to time before present

The alterations in standard deviations were examined between the three major time groups by Fisher-test, by comparing differences between time group 1 and 3. A complete set of these analyses can be found for both sexes in appendix 12. A summarizing graph showing the significant and borderline alterations of the standard deviations, the latter changes ones only significant before the application of Bonferroni's correction, could be seen in Figure 20.

In males, after application of Bonferroni's correction for multiple comparisons, generally, a significant increase of standard deviations for some of the variables was found. Only the left cranial intervertebral foramen width at C3 and the transverse process width at level L5 show a significant decrease. A significant increase of standard deviations was found for a few measurements, such as e.g., ventral vertebral body height at level C7 or for transverse diameter of the vertebral body at level L1. Multiple levels of sagittal diameter of the vertebral body and of the spinal canal, as well as selected intervertebral foramen widths, show only significant alterations of standard deviations before Bonferroni's correction.

In females, a significant increase of standard deviations can be found for the age group classification. After Bonferroni's correction for multiple comparisons, only the right cranial intervertebral foramen width on level L5 shows a significant positive increase of standard deviations. Furthermore, all long bone measurements show a positive secular trend for the standard deviations in females. Without Bonferroni's correction, more intervertebral foramen widths at selected levels as well as few, mostly cervical, spinal measurements express an increase of standard deviations.

No variable shows in both sexes, after Bonferroni's correction, a significant alteration of the standard deviations. In general, more variables in males show significant changes in standard deviations, before or after Bonferroni's correction, than do in females. The ventral vertebral body height on level C7 and the transverse process width on level L5 show a significant increase or decrease, respectively, after Bonferroni's adjustment in males, with females showing a significant change for this particular structure only before Bonferroni's correction. The significant alterations in female dimensions e.g., the long bone measurements do not have significant male counterparts. Both, C3 and C7 dorsal vertebral body heights, show in males and females significant increases in standard deviations only before the Bonferroni correction.

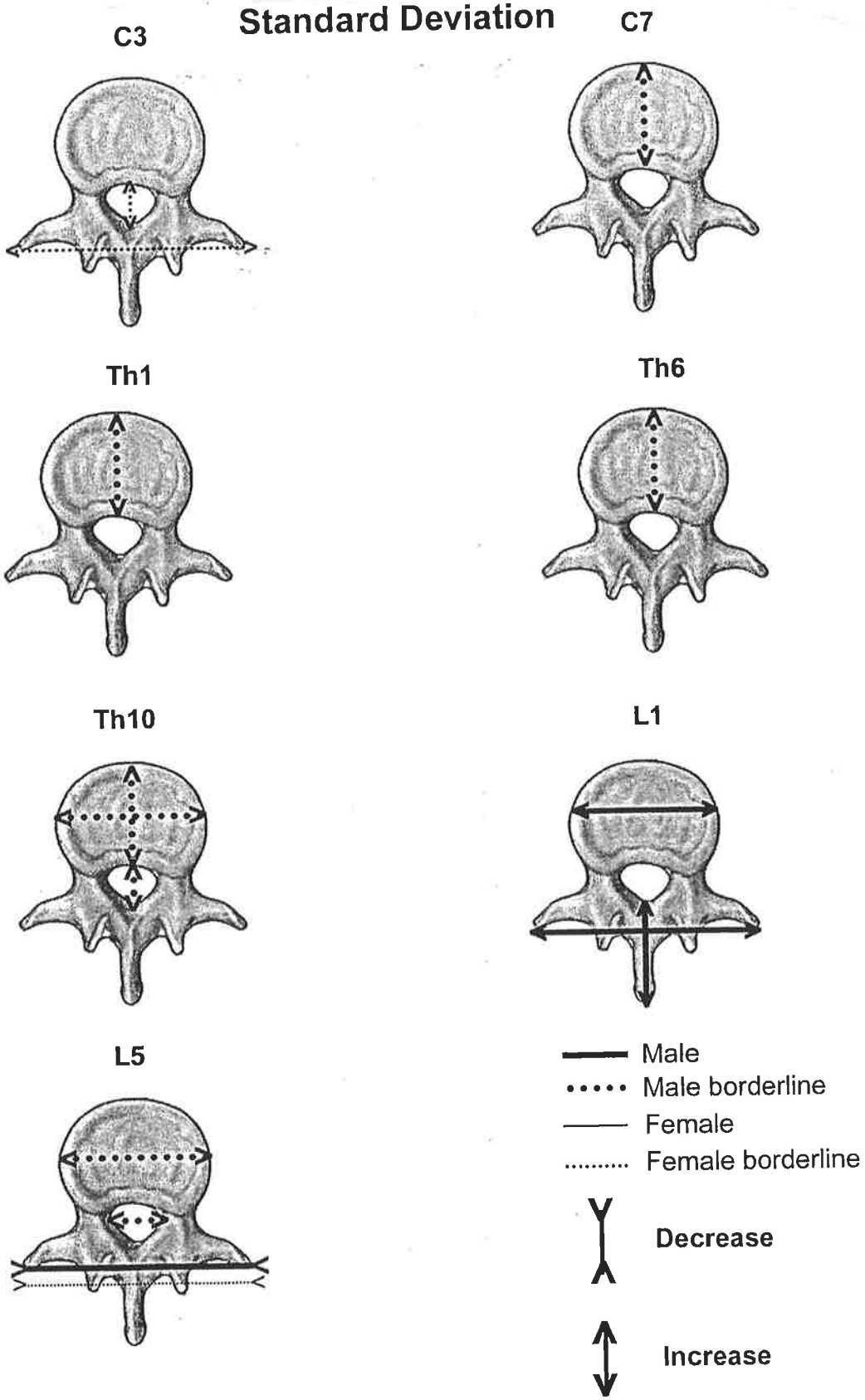


Figure 20: Significant and borderline alterations of standard deviations values between Neolithic / Bronze Age and modern samples

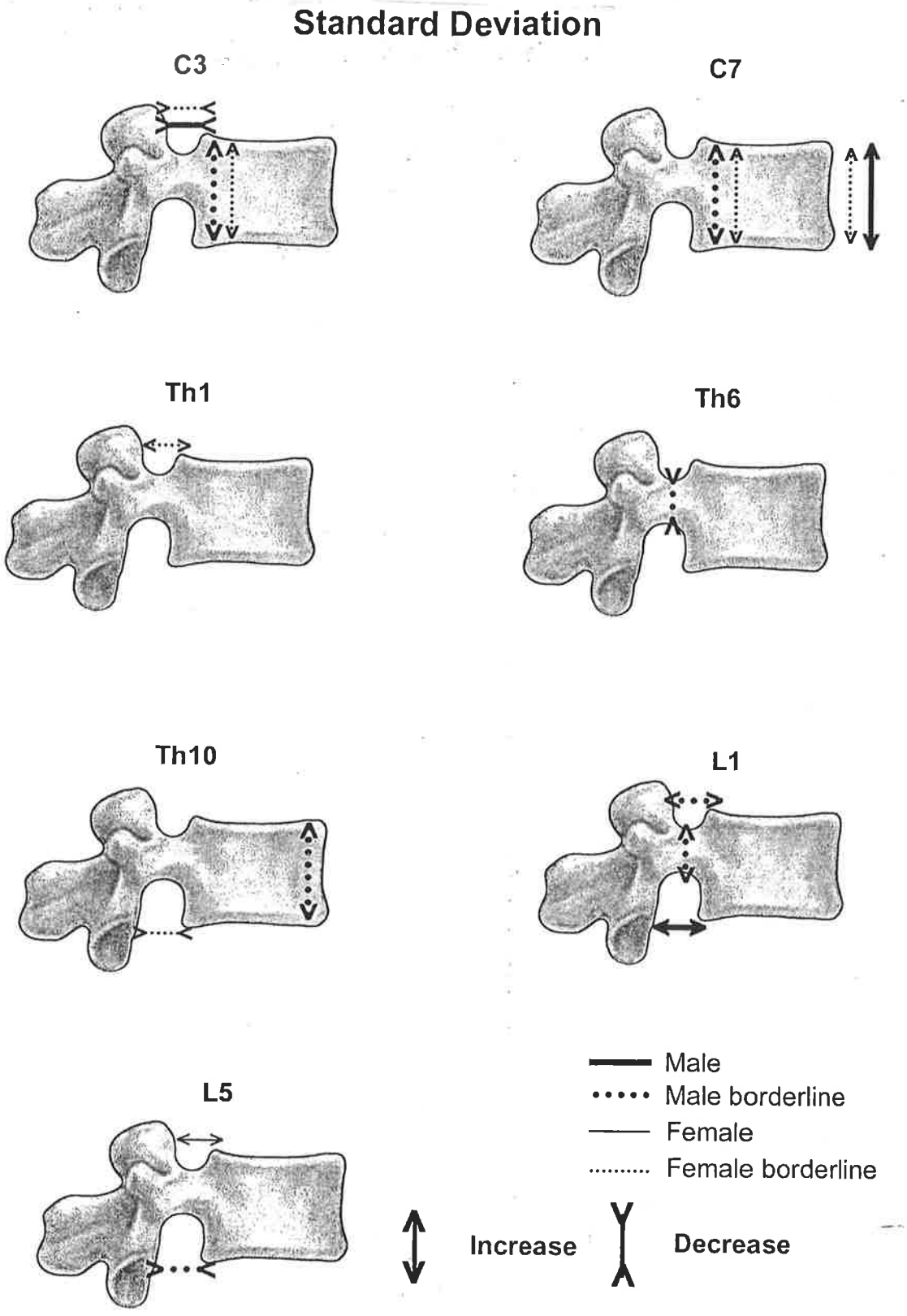


Figure 20 (cont.): Significant and borderline alterations of standard deviations values between Neolithic / Bronze Age and modern samples

Principal components analysis of the spinal variables

Principal component analysis of the spinal measurements was done separately for each sex and for the first five components only. In males, these components accounted for approximately 49% of variation, whereas in females they influence approximately 57% of the spinal variation. In both sexes, the first components seem to be linked to size, with the second most influential one to be linked to the size of the neural pathways. As seen in Figures 21, the two major components, both in males and in females, do not show a clear trend. A complete data set for the principal components analysis could be found in appendix 14.

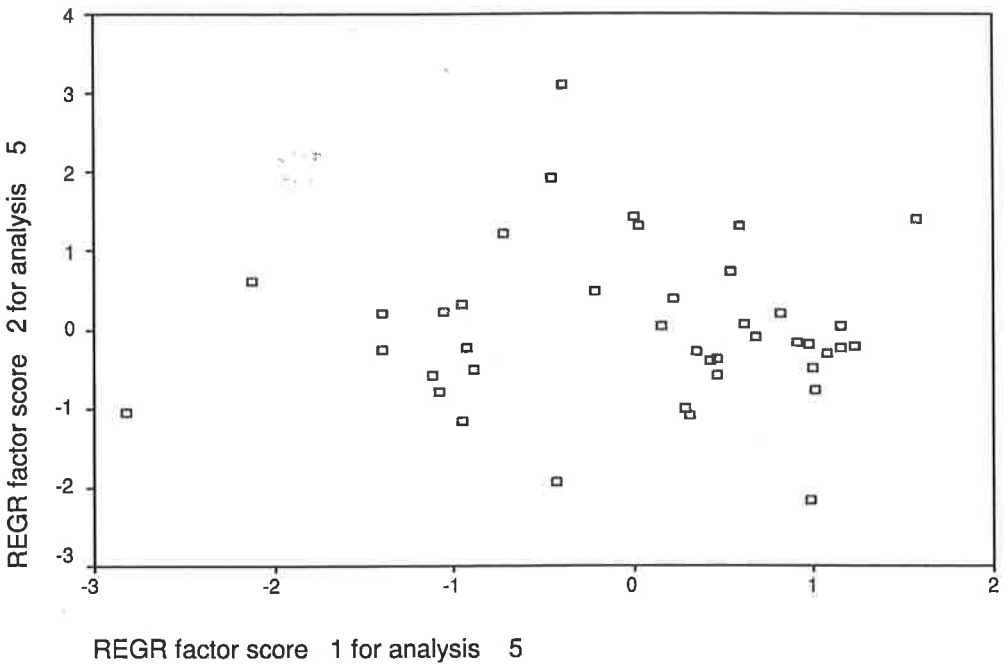


Figure 21: Principal components 1 and 2 of males in modern samples

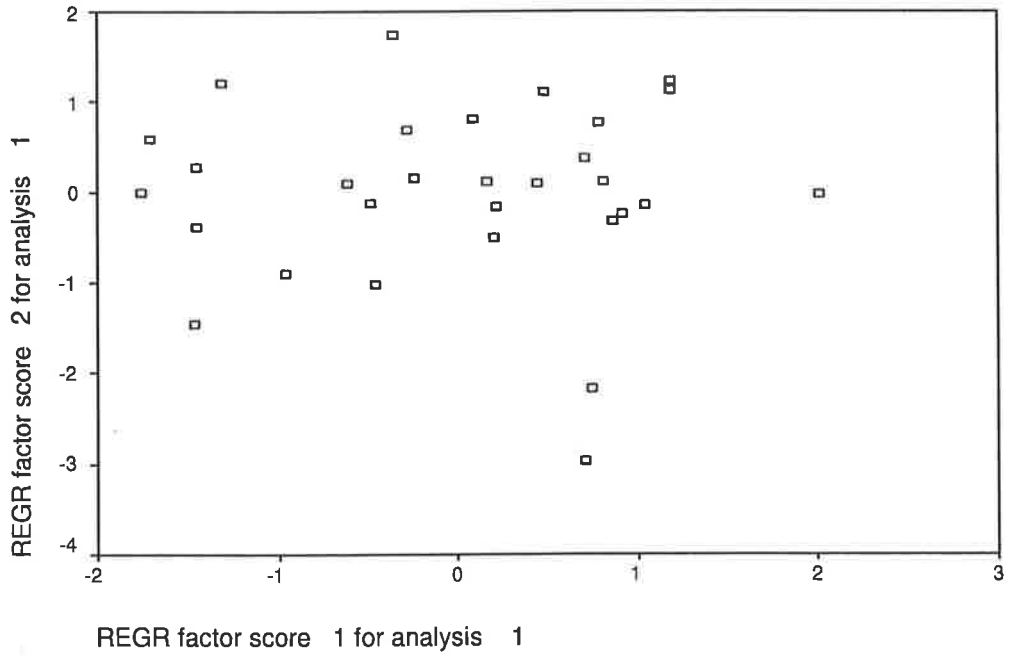


Figure 21 (cont.): Principal components 1 and 2 of females in modern samples

Discussion

Osteometric knowledge of historic spines

The results of the present study allow a deeper insight into the osteometric variability of the human spine, not only based on sex and individual aging, but also in particular with a special focus on the possible implications of various historic time periods. The osteometric knowledge of historic spines has been elaborated, as could be seen in Table 1, but, surprisingly, a microevolutionary perspective of historic spines has been mostly neglected so far.

Until now, most measurements of historic human vertebral column had some limitations either of numerical (small sample size), geographical (just one major area covered) or methodological nature (different methods used or just radiological measurements). Furthermore, the majority of previous studies were undertaken with a direct clinical perspective; see also Table 2. For example, Huizinga *et al.* (1952) used 19th century skeletons due to the lack of sufficient recent sources to explore the osseous dimensions of the lumbar spinal canal with a clinical aim. Scoles *et al.* (1988) also mention that the knowledge of vertebral morphology was still limited, therefore, they provided measurements gained on macerated thoraco-lumbar spine sections.

So far the most similar study on the spinal osteometry from a historic perspective has been conducted by Jankauskas (1994). He found that the variability of spinal measurements in historic Lithuanian populations displayed no microevolutionary trend. According to Jankauskas (1994) the known osteometric spinal data, with their lack of microevolutionary trends, postulate their restricted value for European inter-populational studies. Based on the findings of the study presented here, this statement

must be revised at least for some of the spinal osteometry. Jankauskas (1992), furthermore, did also not report any secular change in the occurrence of spinal pathologies. This was not an issue for the present study, but offers a glimpse of how further research could continue, by focusing on the microevolutionary trends of particular spinal pathologies as rarely done so far (Rothschild and Rothschild, 1996; Henneberg and Henneberg, 1999).

To summarize, it is striking to see that historic studies on large spinal samples and addressing morphometric variations are still rare, whereas for other main body parts, such studies have been conducted in abundant form and major secular trends are well known, as already highlighted above. The outline of the study presented here was to address this lack of knowledge by evaluating the impact of sex, individual age and historic time period on the morphometry of the human spine in Central Europe; this despite the awareness of a plethora of possible biases, which are unfortunately inevitable in such a historic skeletal study.

Study limitations

Microevolutionary changes reconstructed from sometimes very incomplete fossil and skeletal records are full of pitfalls, such as differences between methods of weight and stature estimation or completeness of skeleton (De Miguel and Henneberg, 1999). The general osteological paradoxes that skeletons in fact represent the non-survivors in a certain population (Wood *et al.*, 1992), have to be remembered while doing microevolutionary data interpretation as well. Osteological collections of historic populations may have an additional selection bias, since some specimens with highest quality preservation or the ones showing interesting pathologies, which might be

completely unlinked to the spine, could have been stored separately. Furthermore, the least preserved skeletons may not be included in any survey at all. For example, in a 10^{th}-12^{th} century cemetery, only 82% of all vertebrae were preserved (Swedborg, 1974). These missing individuals might already have been in their lifetime the ones with the most gracile skeleton. Furthermore, usually a large number of the preserved skeletons show at least macroscopically detectable pathologies, not to mention the ones, which might have microscopic level alterations making them not to be representative for the normative healthy population. The ones with macroscopic defects at least were excluded in a study.

The variability of origin of the selected samples in the present study is another problem to be addressed. The cultural and geographical-genetical variation of the included samples might be a possible drawback for a generalization of the findings. Theoretically, such a study on changing morphology might show results that are more obvious by focusing on samples from a single location only, by avoiding influences such as major genetic polymorphism or different environment. Allbrook (1955) already stated medically important as well as unimportant variants of the spine could be resulting from genetical polymorphism. For example, Wetzel (1910) in his report on spinal osteometry highlighted the fact that the European inhabitants differ remarkably. However, even if there is a high morphological variation present, this may not be true for all parts of the human body. As Formicola and Franceschi (1996) reported on the estimated Neolithic body height in Europe, such a variability must not impact on individual height. They found low standard deviations of less than 4% for the total length of the vertebral column in a vast sample. It is not clear if in the present study the selected samples of different origin and, therefore, possibly morphological variability,

significantly cloud the examined underlying morphological alterations. To explore this, one must remeasure in a similar way an even more homogenous sample and would have to compare the found range of variability.

The fact that the here chosen sample could represent a biased population, may be highlighted by Martin (1928) saying, that the Swiss Neolithic and especially the Bajuwar sample, show exceptionally strong development of humeral muscle marks, a direct sign of individual muscular activity. Therefore, the here selected samples, mostly consisting of South German and Swiss populations, may bias the findings that would otherwise be even more obvious. Unlike earlier reports of microevolutionary trends in Central European modern *Homo sapiens*, especially the Swiss people, seem not to show a major shift in body size at least since the Late Roman Periods (Wurm, 1982). In the present study especially the tall stature of the Medieval Age samples, originating from Switzerland and Southern Germany, is astonishing. Wurm (1982) explains similar findings with a possible higher content of milk proteins in diet of people originating from the Alpine and Swiss area. According to him, in the Alps through most time of the modern history intensive stock farming was always present. The trends between levels of protein intake and adult stature, as shown by Wurm (1982), would be correct for most of Germany, but apparently not for the even more alpine Swiss area. Additionally, socio-economic factors may interfere with individual stature, and Wurm (1982) concludes, that for the highest social classes there might not have been any such impact on stature at all. Nevertheless, other reports on secular trends in stature did not find a strong dependence of it on socio-economic levels (Henneberg and Van den Berg, 1990; Henneberg, 2001b). Therefore, it is unclear whether and if so, in which way social

discrepancies between today geographically Swiss and German populations increased the suggested nutrition-based stature differences.

Additionally, any *post-mortem* alterations of the spinal column are affecting its morphology. How much the process of skeletonizing alters the spinal morphology has still to be fully explored. Any macerated bone does not precisely represent its size *in vivo*. For the femur, as an example, Martin and Saller (1957) list a *post mortem* shrinking of 2.3 mm - 2.6 mm, and for the humerus one of 1.3 mm. By including the cartilaginous part, this amount increases up to 7.1 mm for the femur and 4.1 mm for the humerus. Todd and Pyle (1928b) addressed the *post mortem* alterations of spinal morphology and provide absolute values for the intervertebral discs. *Post mortem* alterations of the spine have been discussed in the literature also in particular for the intervertebral disc (Jacobi, 1927; Adams *et al.*, 1994). The lack of intervertebral disc and other soft tissue components such as ligamentum flavum cannot be overcome in osteometric studies. This is in particular true as for the study presented here, if one tries to establish links between found osteometric alterations and possible clinical symptoms usually crucially depending on soft-tissue processes. The effect of drying on the vertebral column seems to reach its final stage after a few weeks and contributes to a bit less than 3% of the total column length, which if far more than for other human bones (Todd and Pyle, 1928a). Furthermore, the extent of drying of the vertebral column seems to vary for all parts at least of the vertebral body. Todd and Pyle (1928a) found a lower relative shrinkage for the ventral aspects of the vertebral body and declare any shrinkage of the articular processes to be negliable. Therefore, osteometric measures do always slightly differ from *in vivo* dimensions.

Furthermore, *intra vitam* pathologies affect the spinal morphology. Minor osteophytic alterations were not a reason for exclusion of vertebral columns from the present study as long as they were regarded as common age-related adaptations and did not interfere with the selected measurements. To highlight this, one has to be aware of the high frequency of such alterations as already reported earlier (Bailey and Casamajor, 1911; Hurxthal, 1968; Hukuda *et al.*, 2000). For example, Nathan (1962) stated that in a sample of 400 recent vertebral columns by an age in the forties all individuals showed at least early stage osteophytes on some of the vertebrae and, therefore, such mild changes can not be regarded as a pathology. Jankauskas (1992) found the onset of spinal degenerative changes to be in his archaeologic sample at around 25-30 years of age for osteophytes or even younger in cases of Schmorl's nodes. In studies of cadavers of various inter-populational origin, done by Eisenstein (1977; 1980), between 25 % and 56% of the skeletons showed some form of osteophytes. Also Park (1980) lists that 95% of people aged 70 years of both sexes will show age-related degenerative spondylosis in the lower lumbar spine. In a clinical study involving individuals who did not show any neurological signs, Pallis *et al.* (1954) found on X-rays of the cervical spine in a sample after 50 years moderate or severe canal narrowing or foraminal narrowing in 76% and 72% respectively. Surprisingly, the prevalence and severity did not further increase in this sample after 50 years of age. Marginal osteophytes at the ventral border of the vertebral bodies were present in 82% of individuals. Based on all these reports, one may more easily approve the chosen approach in terms of minor age-related spinal alterations. Secondary degenerative changes, which involve osteophytes or soft tissue alteration, such as increased thickness of ligamentum flavum or bulging of the

intervertebral disc, are the main etiologies of most cases of spinal stenosis in modern clinical situations. These changes cannot be explored in such microevolutionary osteometric study including non-degenerative spinal columns only. Nevertheless, there are significant correlations between the osseous and soft tissue aspects of the spinal column described, such as between the posterior disc and intervertebral foramen height or between the cross-sectional areas of the foramen and the related nerve roots (Hasegawa *et al.*, 1995). Thus, by obtaining osseous measures, to a limited extent only one may assess the living soft tissue involving conditions.

How far the osseous outline of the spinal canal and its major content, the spinal cord, are correlated, needs to be further evaluated. Preliminary results by Humphreys *et al.* (1998) show that the ratio of these two structures in the cervical spine changes during adulthood. If there were a consistent correlation of these two structures, this would help to draw conclusion on neural pathways by obtaining osseous measurements only.

The true size of the intervertebral foramen, as another example, can only roughly be assessed by its known osteometric diameters. Even plain radiography does not allow accurately enough to determine this crucially on the presence of soft tissue depending structure (Stephens *et al.*, 1991). To assess the overall size of the intervertebral foramen it would be necessary to know the height of the intervertebral discs as well as their contribution to the height of the intervertebral foramen. Therefore, one has to rely for this on data gained from clinical or cadaveric studies (Jacobi, 1927; Yu *et al.*, 1991; Humphreys *et al.*, 1998; Tribus and Belanger, 2001).

Furthermore, the rather small sample sizes in historic spinal studies have statistical advantages and disadvantages. Type I-errors are limited, but the ability to find

real findings is more difficult, resulting in type II errors. The critical sample size, the extent, and the importance of possible errors of measurement have already been addressed above.

Beside genetic influences or individual age, clinical conditions, such as fractures, drug application or various bone diseases, influence the spinal morphometry. Without background information on historic skeletons, it may be hard to know if such an altering situation was present and the gained data can be regarded as normative at least for the time period and geographic background only.

Another issue is raised by the question how far osteometric findings on a particular vertebral level can be generalized for neighbouring levels or whole spinal regions. To address the interrelation between osteometric spinal measurements Jankauskas (1994) performed a cluster-analysis with both sexes pooled, since inter-sexual differences in correlation coefficient were minimal. He found two main clusters: one of longitudinal measurements and one of the transverse diameters. The inter-sexual differences are not negligible in the study presented here. Nevertheless, in the present study dimensions of vertebrae are most strongly correlated with each other at neighbouring levels, as already found in earlier studies (Hermann *et al.*, 1993), as could also seen in Table 10. As also listed in appendix 9, similar measurements of different vertebral levels correlate generally better than non-related measurements. To conclude, based on the data provided by Herrmann *et al.* (1993) and by the present study, one may assume that by comparing selected vertebral levels a found trend can be mostly generalized for the whole vertebral column.

Table 10: Inter-correlation of anterior vertebral body height at various levels, measured on X-rays; *=significant at $p<0.05$ (Hermann *et al.*, 1993)

Level	**Males**			**Females**		
	(N=43)			**(N=70)**		
	Th6	**L1**	**L5**	**Th6**	**L1**	**L5**
Th10	0.29	0.56*	0.29	0.52*	0.45*	0.45*
L1	0.28	-	0.53*	0.35*	-	0.45*
L5	0.23	0.29	-	0.51*	0.45*	-

Comparative analysis of the results

It has been assumed and shown in previous work that spinal morphometric ratios follow a normal or Gaussian distribution (Minne *et al.*, 1988; Black *et al.*, 1991; Xu *et al.*, 1995). This is the case, for most of the investigated spinal traits in the present study as well. Similar sample sizes for both sexes were chosen and both sexes show overall similar age distribution facilitating further the interpretation of the results.

The main vertebral body diameters were measured in the present study since they reflect major mechanical players of the spine, as already outlined above. Piontek (1973) found an increase of massiveness of the vertebral bodies caudally. This seems to be related to the increased load bearing. It is well known that such loading on the spine can be much higher, depending on the body position, than only the normally neutral up to 60% of total body weight in the lower lumbar spine. Silva *et al.* (1997) declared that trabecular anisotropy of the human bone is crucial in load distribution within the spinal column. Thus, it would be worth further investigation how trabecular anisotropy not only changes within individuals, but also if it shows any detectable microevolutionary trend. The reports of vertebral body dimensions with measurements comparable to the ones used in the present study, with means for the whole sample as well as the mean for the modern subgroups, are listed in Tables 11-15 and 17. One can see that the vast majority of the osteometric dimensions measured in the present study fall clearly within the range of earlier reports. Furthermore, one may notice the wide range of reported osteometric values, which might have been caused by the geographically and stature-wise heterogenic samples. This will be further addressed below, with a particular focus on the influence of individual stature on vertebral dimensions for the present study.

Table 11: Vertebral body height (mm) of various samples; measurements similar to Martin (1928)

Level / Sample	Ventral males	Dorsal males	Ventral females	Dorsal females	Reference
C3					
Shanidar 1	11.0	12.5			Stewart (1962)
Skhul 1		10.5			Ditto
La Ferrassie 1	12.5				Heim (1976)
Predmosti 3	11.3	12.6			Matiegka
Predmosti 14	13.0	13.0			Ditto
Predmosti 4			10.4	13.0	Ditto
Predmosti 10			11.4		Ditto
Lithuanian Paleopopulations – 1st / 2nd Millenium AD (N males=159, 160; N females=109, 113)	13.4	13.9	12.4	12.5	Jankauskas (1994)
Early Medieval Polish (N males=48, N females= 25)	13.3		12.0		Piontek (1973)
Polish 12th century (N=1)	12	14			Kaliszewska (1966)
Rural 12th-14th century Polish (N males=19, N females=16)	13.4	15.2	12.7	14.3	Piontek and Budzynska (1972)
12th-18th century Polish (N males=25, N females=25)	14.3	13.8	12.5	12.7	Piontek and Zaborowski (1973)
Urban 14th-18th century Polish (N males=18, N females=14)	14.3	15.2	12.5	13.9	Ditto
Germans (N males=10, N females=10, both sexes combined)	15.3	15.4			Kandziora *et al.* (2001)
Polish (N males=56, N females=44)	12.5	14.0	11.2	13.6	Taflinska, cited by Piontek and Budzynska
Japanese (N males=20, N females=10)	14.4	15.2	12.8	14.2	Hasebe (1913)
Bushmen (N males=24, N females=15)	11.4	13.7	10.8	13.3	Duparc, cited by Piontek and Budzynska
Australians (N males=16, N females=10)	11.5	14.2	10.0	13.3	Kruczkiewicz, cited by Piontek and Budzynska
English (?, N both sexes = +/-70)	12.9				Cyriax (1920)
Recent Americans (?, N males=4, N females= 2, both sexes combined)	13.8	14.2			Tominaga *et al.* (1995)
Recent Europeans (N=8)			11.9	12.1	Aeby (1879)

Recent Europeans (N=?, both sexes?)	12.4				Anderson (1883)
American Whites (N=+/-96)	14.1	14.0			Lanier (1939)
Modern French (N=?)	12.5				Ditto
Recent Americans (N = 12, both sexes)		11.6			Panjabi *et al.* (1991a)
Recent Europeans (N=3, both sexes)	13.7	13			Thomson (1913)
Recent Bushman (N males=1, N females=1)	9	10	10	10.5	Ditto
Range of global sample (N=20)	11 - 17	10 - 15			Stewart
Present study (whole sample)	**13.7**	**14.0**	**12.3**	**12.4**	
Present study (modern subgroups)	**14.1**	**14.6**	**12.5**	**12.8**	

C7

Shanidar 1	13.0	14.0			Stewart
Shanidar 2	13.0	14.0			Ditto
La Chapelle–aux-Saints 1	10.6				Trinkaus (1985)
La Chapelle–aux-Saints 1	13.4				Heim
Predmosti 3	13.0	14.5			Matiegka
Predmosti 9	13.0	14.0			Ditto
Predmosti 14		16.0			Ditto
Predmosti 4			11.0	12.3	Ditto
Dolni Vestonice 15			14.7	15.3	Trinkaus (*pers. comm.)*
Lithuanian Paleopopulations (N males=172, 183; N females=118, 126)	14.1	15.0	13.2	13.8	Jankauskas
Early Medieval Polish (N males=50, N females= 32)	14.1		13.5		Piontek
Polish 12th century	14	14			Kaliszewska
Rural 12th-14th century Polish	14.2	18.6	13.8	17.6	Piontek and Budzynska
Urban 14th-18th century Polish	14.2	17.6	14.2	16.6	Ditto
12t-18th century Polish	14.2	15.6	14.2	14.3	Piontek and Zaborowski
Germans (both sexes)	15.1	15.3			Kandziora *et al.*
Polish	13.2	16.8	13.0	15.3	Taflinska
Japanese	14.5	16.8	13.4	15.3	Hasebe
Bushmen	12.6	14.8	12.2	14.2	Duparc
Australians	12.6	14.9	11.8	13.8	Kruczkiewicz

English (?, both sexes)	13.4				Cyriax
Recent Americans (?, N males=4, N females= 2, both sexes combined)	15.8	16.1			Tominaga *et al*
Recent Europeans			12.3	13.3	Aeby
Recent Europeans (both sexes?)	13.0				Anderson
American Whites	14.4	15.0			Lanier
Modern French	13.0				Ditto
Recent Europeans (both sexes)	13.5	14			Thomson
Recent Americans (both sexes)		12.8			Panjabi *et al.*
Recent Bushman	11	10.5	11	11.5	Ditto
Range global sample	11.5 – 16.5	12 – 16.5			Stewart
Present study (whole sample)	**13.9**	**14.9**	**12.9**	**13.6**	
Present study (modern subgroups)	**13.7**	**15.3**	**12.8**	**13.6**	
Th1					
La Chapelle–aux-Saints 1	14.0				Heim
Predmosti 3		17.5			Matiegka
Predmosti 9		15.0			Ditto
Predmosti 14	17.0	18.0			Ditto
Predmosti 4			14.8	15.6	Ditto
Dolni Vestonice 15			15.2		Trinkaus
Lithuanian Paleopopulations (N males=169, 184; N females=115, 126)	16.0	17.4	15.1	16.1	Jankauskas
Early Medieval Polish (N males=48, N females= 38)	16.4		15.4		Piontek
Polish 12th century	16	17			Kaliszewska
Rural 12th-14th century Polish	16.9	19.6	16.1	17.8	Piontek and Budzynska
Urban 14th-18th century Polish	16.5	18.1	14.2	17.1	Ditto
Polish	15.7	18.2	14.9	15.2	Taflinska
English (?, both sexes)	15.5				Cyriax
Japanese	15.7	16.8	14.8	15.4	Hasebe
Bushmen	14.4	14.9	13.4	13.8	Duparc
Australians	14.5	14.5	13.1	14.1	Kruczkiewicz

Recent Germans (N=102, both sexes)	15.2	15.7			Jacobi (1927)
Recent Europeans			14.3	15.3	Aeby
Recent Europeans (both sexes?)	14.8	15.9			Anderson
American Whites	16.2	17.3			Lanier
American Whites (N=43)	15.9	17.1			Todd and Pyle (1928b)
Modern French	14.5				Ditto
Recent Europeans (both sexes)	15.5	16			Thomson
Recent Americans (both sexes)		14.1			Panjabi *et al.* (1991b)
Recent Bushman	12	11.5	13	13.5	Ditto
Present study (whole sample)	**16.0**	**17.2**	**14.6**	**15.6**	
Present study (modern subgroups)	**16.0**	**17.3**	**14.5**	**15.7**	

Th6

Predmosti 4				17.3	Matiegka
Lithuanian Paleopopulations (N males= 152, 170; N females= 103, 108)	19.1	21.0	17.8	19.6	Jankauskas
Early Medieval Polish (N males=50, N females= 41)	19.8		18.3		Piontek
Polish 12th century	19	19			Kaliszewska
Rural 12th-14th century Polish	20.1	27.7	19.2	23.6	Piontek and Budzynska
Urban 14th-18th century Polish	20.0	26.0	18.5	22.7	Ditto
Swiss (N males= 18, N females=15, both sexes and sides combined)	18.6	20.8			Marchesi *et al.* (1988)
Canadians (recent?, N=10, both sexes?)	17.5				Cotterill *et al.* (1986)
English (?, both sexes)	18.3				Cyriax
Polish	18.9	26.2	18.0	23.6	Taflinska
Japanese	19.0	23.9	17.0	21.2	Hasebe
Bushmen	17.3	20.4	16.4	20.0	Duparc
Australians	16.6	21.9	15.1	19.4	Kruczkiewicz
Recent Germans (both sexes)	17.1	19.0			Jacobi
Recent Americans (both sexes)		17.4			Panjabi *et al.*
Recent Europeans			16.9	19.5	Aeby
Recent Europeans (both sexes?)	18.1	19.9			Anderson

American Whites	19.0	20.8			Lanier
American Whites	18.7	20.6			Todd and Pyle
Recent Europeans (both sexes)	19	20.7			Thomson
Bushman	17	18	17	16.5	Ditto
Present study (whole sample)	**19.0**	**20.9**	**17.5**	**19.2**	
Present study (modern subgroups)	**19.0**	**21.0**	**17.7**	**19.8**	
Th10					
Predmosti 3	21.9	21.9			Matiegka
Predmosti 14	22.4				Ditto
Predmosti 4			17.5	18.2	Ditto
Predmosti 10				22.4	Ditto
Dolni Vestonice 15			23.2		Trinkaus
Lithuanian Paleopopulations (N males=152,, 160; N females= 95, 101)	21.4	23.6	20.3	21.9	Jankauskas
Polish, 12th century	21	22			Kaliszewska
Rural 12th-14th century Polish	23.2	31.9	20.9	27.6	Piontek and Budzynska
Urban 14th-18th century Polish	22.9	31.3	21.9	27.3	Ditto
Late 19th century Dutch (N=3, sex?)	22.7				Rosenberg (1899)
Polish	21.8	28.9	20.9	26.9	Taflinska
Japanese	21.5	28.2	19.2	24.5	Hasebe
Swiss (both sexes and sides combined)	21.1	23.2			Marchesi *et al.*
English (?, both sexes)	21.2				Cyriax
Bushmen	19.9	24.6	18.5	23.3	Duparc
Australians	20.1	24.5	18.6	22.2	Kruczkiewicz
Recent Germans (both sexes)	21.0	21.3			Jacobi
Recent Europeans			21.7	22.2	Aeby
Recent Europeans (both sexes?)	21.0	22.9			Anderson
Recent Europeans (both sexes)	21	22.3			Thomson
Recent Bushman (N males=2, N females=1)	20	19.8	19	19	Ditto
Italians, premenopausal (N=50)			28.2	28.7	Diacinti *et al.* (1995)
Italians, postmenopausal (N=76)			26.2	26.8	Ditto

Recent Americans (both sexes)		20.2			Panjabi *et al.*
American Whites	22.3	23.7			Lanier
American Whites	21.5	23.1			Todd and Pyle
Present study (whole sample)	**22.2**	**23.7**	**20.9**	**21.7**	
Present study (modern subgroups)	**22.2**	**23.8**	**21.4**	**22.1**	
L1					
Predmosti 10			25.0		Matiegka
Dolni Vestonice 15			22.4	26.7	Trinkaus
Téviec (N males=3, N females=4)	23.3	26.3	23	25.5	Vallois (1977)
Lithuanian Paleopopulations (N males= 171, 180 ; N females= 96, 103)	24.9	27.8	24.5	20.4	Jankauskas
Early Medieval Polish (N males=50, N females= 45)	26.3		25.3		Piontek
Polish 12th century	22	27			Kaliszewska
Rural 12th-14th century Polish	26.1	34.4	25.5	29.5	Piontek and Budzynska
Urban 14th-18th century Polish	26.4	32.8	25.3	28.8	Ditto
Late 19th century Dutch (sex?)	24				Rosenberg
English (?, both sexes)	24.4				Cyriax
Polish	24.9	30.4	24.5	29.5	Taflinska
Swiss (both sexes and sides combined)	25.9	27.2			Marchesi *et al.*
Japanese	23.2	25.9	23.8	26.7	Hasebe
Bushmen	22.1	27.3	22.7	24.6	Duparc
Australians	25.3	31.4	22.0	25.1	Kruczkiewicz
Americans (N=30, both sexes)	25.0	25.8			Berry *et al.* (1987)
Recent Germans (both sexes)	24.5	25.7			Jacobi
Recent Americans (both sexes)		23.8			Panjabi *et al.*
Recent Europeans			25.6	26.0	Aeby
Recent Europeans (both sexes?)	24.6	26.5			Anderson
Italians, premenopausal			33.1	33.3	Diacinti *et al.*
Italians, postmenopausal			29.4	31.4	Ditto
American Whites	26.2	28.3			Lanier
American Whites	25.7	27.3			Todd and Pyle

Recent Europeans (both sexes)	24.3	26.3			Thomson
Recent Bushman (N males=2, N females=1)	22.3	23.8	21.5	22	Ditto
Recent Europeans (N males =2; N females=2, combined)		28			Boszczyk *et al.* (2001)
Present study (whole sample)	**25.8**	**28.0**	**24.7**	**26.3**	
Present study (modern subgroups)	**25.5**	**27.9**	**25.0**	**26.4**	
L5					
Predmosti 3	29.4	23.0			Matiegka
Predmosti 14		20.5			Ditto
Predmosti 4			27.0	20.6	Ditto
Predmosti 10				23.5	Ditto
Téviec (N males=4, N females=3)	24.5	20.5	22.2	22.5	Vallois
Lithuanian Paleopopulations (N males= 170, 188 ; N females=105, 124)	28.0	23.4	26.2	22.2	Jankauskas
Early Medieval Polish (N males=48, N females= 41)	29.4		27.7		Piontek
Polish 12th century	22				Kaliszewska
Rural 12th-14th century Polish	29.3	35.7	28.1	32.6	Ditto
Urban 14th-18th century Polish	29.4	34.3	28.2	32.9	Piontek and Budzynska
Late 19th century Dutch (sex?)	227.7				Rosenberg
English (?, both sexes)	27.8				Cyriax
Polish	28.7	34.7	26.9	32.4	Taflinska
Swiss (both sexes and sides)	28.9	24.7			Marchesi *et al.*
Japanese	27.5	34.6	25.6	31.8	Hasebe
Bushmen	24.4	30.5	24.8	30.1	Duparc
Australians	24.3	30.8	23.0	29.9	Kruczkiewicz
Recent Americans (both sexes)		22.9			Panjabi *et al*
Americans (both sexes)	28.7	23.1			Berry *et al.*
Recent Europeans			29.8	23.6	Aeby
Recent Europeans (both sexes?)	27.2	22.2			Anderson
Italians, premenopausal			35.3	32.5	Diacinti *et al.*
Italians, postmenopausal			34.1	30.6	Ditto

American Whites	28.9	29.1			Lanier
American Whites	28.1	23.7			Todd and Pyle
Recent Europeans (both sexes)	29	21			Thomson
Recent Bushman (N males=2, N females=1)	24.3	22	23	20	Ditto
Recent Europeans (both sexes)		23			Boszczyk *et al.*
Present study (whole sample)	**28.6**	**24.5**	**27.0**	**23.4**	
Present study (modern subgroup)	**28.9**	**24.1**	**28.1**	**23.6**	

Table 12: Vertebral body diameters (mm) of various samples, measurements similar to Martin (1928)

Level / Sample	Sagittal males	Transverse males	Sagittal females	Transverse males	Reference
C3					
Early Medieval Polish (N males=48, N females=25/26)	15.6	23.3	14.0	21.3	Piontek (1973)
12th- 18th century Polish (N males=25, N females=25)	16.0	20.0	14.2	18.6	Piontek and (1973)
English (N both sexes=+/-70)		20.9			Cyriax (1920)
Europeans (N=3, both sexes)	15.2	23.8			Aeby (1879)
Europeans (N=28, both sexes?)	15.2				Anderson (1883)
Europeans (N males=5, N females= 8)	15.0	23.1	13.3	21.0	Thomson (1913)
Russians (N males=28?, N females=10?)	13	23.5	12		Stefko (1926)
Bushman (N males=1, N females=1)	12.5	18	12	21	Ditto
Present study (whole sample)	**16.0**	**19.3**	**14.8**	**18.5**	
Present study (modern subgroups)	**16.2**	**19.3**	**14.7**	**18.1**	
C7					
Early Medieval Polish (N males=50, N females=32)	18.3	29.4	16.8	27.5	Piontek
12th-18th century Polish	16.9	27.0	16.2	25.6	Piontek and Zaborowski
Europeans	16.2	28.5	15.6	26.2	Aeby
Europeans (both sexes?)	18.3				Anderson
Europeans (both sexes)	16	31.3			Thomson
English (both sexes)		29.2			Cyriax
Russians (N males=28?, N females=10?)	16	30	14		Stefko
Bushmen (N males=2, N females=1)	14	27	12	26	Thomson
Present study (whole sample)	**17.1**	**26.5**	**15.6**	**24.8**	
Present study (modern subgroups)	**17.7**	**26.6**	**16.0**	**24.4**	

Th1

Early Medieval Polish (N males=48, N females=36/38)	27.5	31.1	24.2	28.1	Piontek
Americans (N males=25, N females=25)	15.5	26.4	15.3	26.7	Berry *et al.* (1987)
Europeans	16.6	29.3	15.4	27.9	Aeby
English (both sexes)		30.4			Cyriax
Europeans (both sexes?)	17.3				Anderson
Europeans (both sexes)	16.3	28.3			Thomson
Russians (N males=28?, N females=10?)	17	30.5	15		Stefko
Bushmen (N males=1, N females=1)	14	24	13	24	Ditto
Present study (whole sample)	**17.8**	**28.5**	**15.8**	**26.2**	
Present study (modern subgroups)	**17.8**	**28.9**	**16.0**	**26.1**	

Th 6

Early Medieval Polish (N males=50, N females=42/41)	27.5	31.1	24.2	28.1	Piontek
Canadians (N =10, both sexes?)	21.8	25.1			Cotterill *et al.* (1986)
Europeans	25.9	29.9	24.5	26.9	Aeby
Americans	23.7	28.7	21.9	26.0	Berry *et al.* (1987)
Europeans (both sexes?)	25.6				Anderson
Europeans (both sexes)	24.3	25.7			Thomson
Russians (N males=28?, N females=10?)	23	30.5	20		Stefko
Bushmen (N males=1, N females=1)	18	21	19	20	Ditto
Present study (whole sample)	**25.6**	**27.8**	**22.9**	**24.8**	
Present study (modern subgroups)	**26.3**	**27.9**	**23.6**	**24.6**	

Th10

Europeans	30.5	36.2	29.0	33.1	Aeby
English (both sexes)		34.0			Cyriax
Europeans (both sexes?)	29.4				Anderson
Europeans (both sexes)	28.3	30.7			Thomson
Russians (N males=28?, N females=10?)	23	38	22		Stefko
Bushmen (N males=2, N females=1)	23.5	26	22	22	Ditto
Present study (whole sample)	**30.0**	**34.2**	**26.2**	**30.4**	

Present study (modern subgroups)	**31.3**	**34.7**	**27.3**	**31.0**	
L1					
Early Medieval Polish (N males=50, N females=45)	33.2	47.2	29.6	42	Piontek
Americans (N=30, both sexes)	28.9	39.5			Berry *et al.*
English (both sexes)		39.2			Cyriax
Italians (N = 63, both sexes)	29.0	41.0			Postacchini *et al.* (1983)
Indians (N=58, both sexes)	25.0	36.0			Ditto
Europeans	32.7	46.0	29.3	41.3	Aeby
Europeans (both sexes?)	29.9				Anderson
Europeans	28.7	37.7			Thomson
Russians (N males=28?, N females=10?)	28	48	28		Stefko
Bushmen (N males=2, N females=1)	24	33	21	27	Ditto
Americans	29.5	44.3	26.7	38.8	Scoles *et al.* (1988)
Nigerians (N males=79, N females=43)	29.2		26.1		Amonoo-Kuofi (1985)
Caucasoid (N males=78, N females=35)	31	39	27	34	Eisenstein (1977)
Zulu Negroid (N males= 108, N females=54)	28	39	25	35	Ditto
Sotho Negorid (N males= 106, N females=62)	27	38	25	34	Ditto
Present study (whole sample)	**31.7**	**40.3**	**27.6**	**35.5**	
Present study (modern subgroups)	**32.9**	**41.0**	**28.2**	**35.9**	
L5					
Early Medieval Polish (N males=48, females=41/43)	35	55.2	32.5	50.3	Piontek
Europeans	36.2	54.0	33.4	50.6	Aeby
Italians (both sexes)	33.0	49.0			Postacchini *et al.*
Indians (both sexes)	29.0	43.0			Ditto
Americans (both sexes)	32.4	46.1			Berry *et al.*
Americans	34.5	52.9	31.5	48.6	Scoles *et al.*
English (both sexes)		48.0			Cyriax
Nigerians	34.2		31.3		Amonoo-Kuofi
Europeans (both sexes?)	36.5				Anderson

Europeans (both sexes)	30.7	42			Thomson
Russians (N males=28?, N females=10?)	25	54	25		Stefko
Bushmen (N males=2, N females=1)	29.5	38.5	25	34	Ditto
Caucasoid	33	46	30	42	Eisenstein
Zulu Negroid	32	45	31	43	Ditto
Sotho Negorid	33	44	31	42	Ditto
Present study (whole sample)	**33.6**	**47.8**	**31.1**	**44.1**	
Present study (modern subgroups)	**34.5**	**47.7**	**30.4**	**42.6**	

The maximum pedicle height was also explored in the present study, since it could reflect any morphological alterations in particular as a bridging structure between the vertebral body, the laminae and the transverse and spinal process. Pedicle robustness is linked to pedicle function in distribution of force and columnar stress (Shapiro, 1993; Sanders, 1998). Sanders (1998), who basically divided the human spinal column into just two force bearing pillars, already highlighted the extreme steady demand for the pedicles to support bending stress, due to their physiological positions between the two main force bearing pillars, the frontal vertebral bodies and intervertebral discs and the dorsal pillars, consisting of the laminae and the zygoapophyseal joints. Sanders (1998) also emphasizes the importance of the interaction with the ilio-lumbar ligament as another factor in developing typical human lower lumbar pedicle size. Therefore, any alterations of mechanical properties on the human spine would most likely be reflected on the pedicle size. If the increased pedicle area in humans links to the unique upright locomotion is still controversially debated (Davis, 1961; Shapiro, 1993) and was not an issue in the present study. For clinical purposes, Banta *et al.* (1989) recommended to list rather maximal values instead of the usual standard deviations for reports on the pedicle size. Nevertheless, the particular effective dimension of the pedicles they measured is not of real value for osteometric analysis.

The impact of individual stature on pedicle dimensions has been addressed equivocally so far. Scoles *et al.* (1988) found no clear link between pedicle dimensions and individual size, unlike for the correlation between vertebral body height and stature. On the other hand, Karaikovic *et al.* (1997) describe a correlation between pedicle

dimensions and individual body height, which was also mostly the case in the present study.

A listing of major earlier reports of pedicle height dimensions together with the means of the whole sample presented here as well as the modern sample could be found in Table 13.

Table 13: Maximum pedicle height (mm) of various samples

Level / Sample	Pedicle height - right	Pedicle height - left	Reference
C3			
Americans (both sexes, N=12)	7.6	7.2	Panjabi *et al.* (1991a)
Recent Americans (?, N males=4, N females=2, both sexes combined, side?)	7.5		Tominaga *et al.* (1995)
Recent Americans (?, N males=25, N females=15, both sides combined)	6.8 (m) / 4.7 (f)?		Ebraheim *et al.* (1997)
Germans (N males=10, N females=10, both sexes combined, side?)	7.4		Kandziora *et al.* (2001)
Present study (whole sample)	**6.9 (m) / 6.1 (f)**	**7.0 (m) / 6.1 (f)**	
Present study (modern subgroups)	**7.3 (m) / 6.3 (f)**	**7.3 (m) / 6.2 (f)**	
C7			
Americans (both sexes)	7.5	7.5	Panjabi *et al.*
Americans (N males=32, N females=24, side?)	7.1 (m) / 7.0 (f)		Xu *et al.* (1995)
Recent Americans (?, N males=4, N females=2, both sexes combined, side?)	7.4		Tominaga *et al.*
Germans (both sexes, sides?)	8.5		Kandziora *et al.*
Present study (whole sample)	**7.2 (m) / 6.6 (f)**	**7.3 (m) / 6.6 (f)**	
Presents study (modern subgroups)	**7.5 (m) / 6.6 (f)**	**7.5 (m) / 6.5 (f)**	
Th1			
Americans (both sexes)	9.3	9.9	Panjabi *et al.* (1991b)
Americans (N males=25, females=25; side?)	9.2 (m) / 8.4 (f)		Scoles *et al.* (1988)
Present study (whole sample)	**9.2 (m) / 8.4 (f)**	**9.4 (m) / 8.4 (f)**	
Present study (modern subgroups)	**9.1 (m) / 8.3 (f)**	**9.3 (m) / 8.4 (f)**	
Th 6			
Americans / Asians (N males= 8, N females=9, both sexes combined, side?)	10.1		Vaccaro *et al.* (1995)

Americans (both sexes)	12.0	11.6	Panjabi *et al.*
Germans (?, N=4, both sexes?)	11.4		Kothe *et al.* (1996)
Americans	11.5 (m) / 10.6 (f)		Scoles *et al.*
Present study (whole sample)	**12.2 (m) / 10.5 (f)**	**12.0 (m) / 10.4 (f)**	
Present study (modern subgroups)	**12.6 (m) / 10.8 (f)**	**12.2 (m) / 10.5 (f)**	
Th10			
Americans (both sexes)	14.7	15.0	Panjabi *et al.*
Chinese (N males=25, N female=15, side?)	14.4 (m) / 14.2 (f)		Hou *et al.* (1993)
Americans / Asians (both sexes, side?)	14.1		Vaccaro *et al.*
Present study (whole sample)	**15.4 (m) / 14.0 (f)**	**15.5 (m) / 13.9 (f)**	
Present study (modern subgroups)	**15.8 (m) / 14.3 (f)**	**15.7 (m) / 14.3 (f)**	
L1			
Indians (N males= 18, N females=2; side unknown)	15.7 (m) / 15.7 (f)		Mitra *et al.* (2002)
Americans (N males=38, N females=31; side?)	17.0 (m) / 15.3 (f)		Olsewski *et al.* (1990)
Chinese (side?)	15.9 (m) / 15.5 (f)		Hou *et al.*
Americans (both sexes)	15.9	15.8	Panjabi *et al.* (1992)
Americans	15.3 (m) / 14.5 (f)		Scoles *et al.*
Americans (N=30, both sexes)	15.6	15.6	Berry *et al.* (1987)
Present study (whole sample)	**16.0 (m) / 14.5 (f)**	**15.7 (m) / 14.3 (f)**	
Present study (modern subgroups)	**16.5 (m) / 14.6 (f)**	**16.4 (m) / 14.4 (f)**	
L5			
Indians (side unknown)	15.7 (m) / 17.0 (f)		Mitra *et al.*
Americans (N males=47, N females=39, side?)	17.4 (m) / 16.2 (f)		Olsewski *et al.*
Americans (both sexes)	18.0	19.2	Panjabi *et al.*
Americans	16.2 (m) / 18.5 (f)		Scoles *et al.*

Americans	13.8	13.6	Berry *et al.*
Chinese (side?)	20.5 (m) / 18.7 (f)		Hou *et al.*
Present study (whole sample)	**14.6 (m) / 13.5 (f)**	**14.0 (m) / 12.8 (f)**	
Present study (modern subgroups)	**14.5 (m) / 13.3 (f)**	**13.9 (m) / 12.7 (f)**	

The size of the neural canal is a crucial osteometric dimension. The relation between spinal cord and osseous spinal canal size may be important for clinical issues, as pointed out by Panjabi *et al.* (1991a) for the cervical spine. For example, they suggest a possible link between the decrease of the spinal canal / spinal cord ratio from C6 to C7, and the subsequent high vulnerability to neural damage, and the high rate of spinal cord injuries at this level; as shown by Fife and Kraus (1986). Furthermore, in a young asymptomatic clinical sample, Schmid *et al.* (1999) found no body position dependent changes of the cross-sectional areas of the spinal canal when measured at the osseous level, whereas the same measurement on the disc level did change. This means for the present study that due to its independence of body positions, at least in asymptomatic individuals, the spinal canal dimensions at the vertebral body levels may be used for comparison between clinical and skeletal samples. The spinal canal dimensions at the disc level cannot be assessed in osteometric studies anyway.

One has to wonder, how far osseous spinal canal dimensions reflect its content. By having bigger spinal cords, more muscular individuals, may also need larger bony neural spaces; unless they show smaller reserve capacities, which then would predispose them for spinal pathologies. Surprisingly, there is a sexual dimension issue as well. Female and male mammals have similar size of neural nerve roots, as described by Dunn (1912), therefore, relative to body weight, female ones are even bigger than males in this report. In the case of the cervical nerve root, as examined by Dunn (1912), this cannot be due to a higher sex dependent visceral demand such as e.g., in the pelvic region, but must be linked to a higher periphery somato-motoric demand causing larger efferent branches. Nevertheless, in general the sensori-motor demand may be the same

in males and females because it depends on the number of muscle motor units rather than on the size of muscle fibres. One factor to remember, while interpreting osseous dimensions and the possible relation to their neural contents, is the fact that the cervical and lumbar enlargements may vary in level even within one species. Therefore, if one finds a different shape of the osseous spinal canal in a certain fossil or skeleton, any interpretation of its altered neural content must be formulated with caution.

To summarize, conclusions on the size and content of the spinal canal, based on the osseous dimensions only, should to be formulated very cautiously. A comparison of earlier published data of the osseous spinal canal and the measures of this study could be found in Table 14.

Table 14: Neural canal sizes (mm) of various samples, measurements similar to Martin (1928)

Level / Sample	Sagittal males	Transverse males	Sagittal females	Transverse females	Reference
C3					
Predmosti 3	15.6	24.0			Matiegka (1938)
Predmosti 14	15.5	23.0			Ditto
Predmosti 4			15.0	21.5	Ditto
Predmosti 10				18.0	Ditto
Early Medieval Polish (N males=48, N females= 24/26)	14.8	22.6	14.7	21.2	Piontek (1973)
12-18th century Polish (N males=25, N females=25)	15.3	20.0	15.0	21.5	Piontek and Zaborowski (1973)
Recent Americans (?, N males=4, N females=2, both sexes combined)	16.2	24.4			Tominaga *et al.* (1995)
Israelis (N=54, both sexes combined?)		22.5			Gepstein *et al.* (1991)
Japanese (N males=20, N females=10)	13.5	21.5	12.7	21.2	Hasebe (1913)
Europeans (N males=5, N females=8)	16.7	23.9	15.4	23.4	Aeby (1879)
White Americans (N males=100, N females=27)	16.5	23.9	15.5	22.6	Francis (1955)
Black Americans (N males=100, N females=57)	15.2	24.3	15.1	23.2	Ditto
Germans (N males=10, N females=10; both sexes combined)	16.5	24.6			Kandziora *et al.* (2001)
Russians (N=?, both sexes)	15	24			Stefko (1926)
White Americans (N=+/-96)	14.9				Lanier (1939)
Recent Americans (N=12, both sexes)	16.2	22.9			Panjabi *et al.* (1991a)
Recent Europeans (N=3, both sexes)	14.7	22.3			Thomson (1913)
Recent Bushman (N males=1, N females=1)	15	21	14	21	Ditto
Present study (whole sample)	**15.3**	**24.1**	**14.9**	**23.1**	
Present study (modern subgroups)	**15.9**	**24.5**	**15.4**	**23.9**	

C7					
Shanidar 1	16.0	25.0			Stewart (1962)
Predmosti 3	14.0	26.6			Matiegka
Predmosti 9	12.0	22.0			Ditto
Predmosti 14	14.4	27.0			Ditto
Predmosti 4			13.5	22.5	Ditto
Early Medieval Polish (N males=50, N females= 33/35)	14.5	23.3	14.2	22.5	Piontek
12th-18th century Polish	14.6	23.8	15.2	22.9	Piontek and Zaborowski
Recent Americans (?, N males=4, N females=2, both sexes combined)	15.2	26.3			Tominaga *et al*
Israeli (both sexes?)		23.7			Gepstein *et al.*
Japanese	13.8	23.3	12.9	22	Hasebe
Europeans	14.7	25.4	14.3	24.3	Aeby
White Americans	14.4	24.8			Lanier
Germans (both sexes)	15.9	24.6			Kandziora *et al.*
Russians (both sexes)	15.5	22			Stefko
Recent Europeans (both sexes)	14.7	25			Thomson
Recent Bushman	13	21	13	21	Ditto
White Americans	15.5	25.6	14.4	24.4	Francis
Black Americans	15.5	25.5	14.3	24.4	Ditto
Recent Americans (both sexes)	15.2	24.5			Panjabi *et al.*
Global sample (N=20)	12.5 - 17.5	20.0 - 26.0			Stewart
Present study (whole sample)	**14.9**	**25.2**	**14.3**	**24.4**	
Present study (modern subgroups)	**15.1**	**26.1**	**14.5**	**25.7**	
Th1					
Predmosti 3	15.6	24.0			Matiegka
Predmosti 9	11.4	21.4			Ditto
Predmosti 14	14.0	23.3			Ditto

Predmosti 4			14.6	20.4	Ditto
Dolni Vestonice 15				22.3	Trinkaus (*pers. comm.*)
Early Medieval Polish (N males=48, N females=37/41)	15.4	20.3	15	19.8	Piontek
Japanese	14.3	19.9	13.3	19	Hasebe
Europeans	15.5	23.3	15.1	21.4	Aeby
White Americans	14.9	21.6			Lanier
South Africans (N=6, both sexes)	14.3	20.7			Dommisse (1974; 1975)
Americans, all races (N males=25, N females=25)	15.2	21.2	14.2	20.5	Scoles *et al.* (1988)
Russians (both sexes)	16	21			Stefko
Recent Europeans (both sexes)	15	21.3			Thomson
Recent Americans (both sexes)	16.4	21.8			Panjabi *et al.* (1991b)
Recent Bushman	13	13	13	18	Ditto
Present study (whole sample)	**15.4**	**22.4**	**14.9**	**21.3**	
Present study (modern subgroups)	**15.8**	**23.3**	**15,3**	**22.2**	
Th6					
Dolni Vestonice 15				15.8	Trinkaus
Predmosti 3		17.0			Matiegka
Predmosti 9	15.3	15.0			Ditto
Predmosti 14	15.3	15.3			Ditto
Predmosti 4			16.0	17.5	Ditto
Early Medieval Polish (N males=50, N females=42)	15.8	16.2	15.2	15.2	Piontek
Recent Americans (both sexes)	16.5	17.3			Panjabi *et al.*
Japanese	14.8	14.8	14.4	14.6	Hasebe
Canadians (N =10, both sexes?)	14.5	15.1			Cotterill *et al.* (1986)
Swiss (N males= 18, N females=15, both sexes and sides combined)	16.4	17.0			Marchesi *et al.* (1988)
Russians (both sexes)	17	17			Stefko
Europeans	17.3	17.8	16.8	17.2	Aeby
Americans	15.7	16.5	15.2	15.5	Scoles *et al.*
White Americans	15.5	16.6			Lanier

South Africans (both sexes)	13.4	14.9			Dommisse
Recent Europeans (both sexes)	15.7	16.3			Thomson
Bushman	14	15	14	15	Ditto
Present study (whole sample)	**16.3**	**17.3**	**15.9**	**16.6**	
Present study (modern subgroups)	**16.7**	**17.7**	**16.2**	**16.9**	
Th10					
Predmosti 3	15.5	17.3			Trinkaus
Predmosti 4			16.0	17.4	Matiegka
Predmosti 10			14.0	15.0	Ditto
Japanese	14.3	15.2	13.6	15.3	Hasebe
Europeans	17.3	18	16.4	17.5	Aeby
Russians (both sexes)	17	19			Stefko
White Americans	15.3	17.2			Lanier
South Africans (both sexes)	13.5	15.6			Dommisse
Recent Americans (both sexes)	15.5	18.2			Panjabi *et al.*
Recent Europeans (both sexes)	15.3	17.7			Thomson
Recent Bushman	15	16	15	17	Ditto
Swiss (N males= 18, N females=15, both sexes and sides combined)	15.8	17.3			Marchesi *et al.*
Present study (whole sample)	**16.2**	**18.4**	**15.7**	**17.3**	
Present study (modern subgroups)	**16.4**	**18.6**	**16.4**	**17.9**	
L1					
Dolni Vestonice 15				22.7	Trinkaus
Predmosti 3	18.0	25.6			Matiegka
Predmosti 14	16.0	22.3			Ditto
Romano-British (N=?, both sexes)	15.9	22.0			Ditto
Anglo-Saxon (N=?, both sexes)	15.2	21.3			Porter and Pavitt (1987)
Early Medieval Polish (N males=50, N females=45)	17.6	22.3	17.1	21.1	Piontek
19th century Netherlands (N=51, sex?)	18.0	23.4			Huizinga *et al.* (1952)

Nigerians (N males=79, N females=43)	16.6		15.8		Amonoo-Kuofi (1985)
Japanese	16.6	20.3	16	19.7	Hasebe
Japanese (N males=59, N females=21, both sexes combined)	16.2				Kikuchi *et al.* (1977)
Japanese (N=?, sex?)	14.3				Takemitsu *et al.*, cited by Kikuchi *et al.*
Japanese (N=?)	16.6		16.4		Nagashima, cited by Kikuchi *et al.*
Japanese (N= ?, sex?)	16.4				Tsunematsu, cited by Kikuchi *et al.*
Japanese (N=?, sex?)	17.0				Hibi, cited by Kikuchi *et al.*
Japanese (N=?, sex?)	15.6				Okamoto, cited by Kikuchi *et al.*
Israeli (both sexes combined?)		20.8			Gepstein *et al.*
Europeans	18.5	23.9	18.9	22.8	Aeby
Koreans (N males=63, N females=27)	15.4	21.5	15.5	20.5	Lee *et al.* (1995)
Swiss (N males= 18, N females=15, both sexes and sides combined)	17.8	23.5			Marchesi *et al.*
Russians (both sexes)	20	23			Stefko
White Americans	17.2	23.2			Lanier
Italians (N=63, both sexes)	16.7	21.7			Postacchini *et al.* (1983)
Indians (N=58, both sexes)	15.0	19.1			Ditto
Americans (N=30, both sexes)	17.2	22.1			Berry *et al.* (1987)
South Africans (N=25, both sexes)	15.4	20.4			Dommisse
Caucasoid (N males=78, N females=35)	18.0	23.0	18.0	22.0	Eisenstein (1977)
Zulu Negroid (N males= 108, N females=54)	16.0	21.0	17.0	20.0	Ditto
Sotho Negorid (N males= 106, N females=62)	16.0	21.0	16.0	20.0	Ditto
Americans	17.6	22.2	17.7	21.2	Scoles *et al.*
Recent Americans (both sexes)	19.0	23.7			Panjabi *et al.* (1992)
Recent Europeans (both sexes)	15.7	21.3			Thomson
Bushmen (N males=2, N females=1)	15.5	18	14	20	Ditto
Present study (whole sample)	**17.8**	**23.7**	**17.7**	**22.5**	
Present study (modern subgroups)	**18.2**	**24.4**	**18.4**	**23.2**	

L5					
Dolni Vestonice 15				23.1	Trinkaus
Predmosti 3	18.0	27.6			Matiegka
Predmosti 9	15.6	24.3			Ditto
Predmosti 14	17.4	29.9			Ditto
Predmosti 4			18.5		Ditto
Predmosti 10			13.0	26.3	Ditto
Romano-British (both sexes)	15.2	25.7			Ditto
Anglo-Saxon (both sexes)	14.6	25.6			Porter and Pavitt
Early Medieval Polish (N males=48, N females=40/41)	17.3	24.9	16.5	24.1	Piontek
19th century Netherlands (N=51, sex?)	16.9	25.8			Huizinga *et al.*
Israeli (both sexes combined?)		30.0			Gepstein *et al.*
Nigerians	16.0		14.6		Amonoo-Kuofi
Japanese	16.9	26.4	15.6	25	Hasebe
Japanese (both sexes combined)	15.8				Kikuchi *et al.*
Japanese (sex?)	14.3				Takemitsu *et al.*
Japanese	18.3		16.8		Nagashima
Japanese (sex?)	16.3				Tsunematsu
Japanese (sex?)	18.0				Hibi
Japanese (sex?)	16.3				Okamoto
Swiss (N males= 18, N females=15, both sexes and sides combined)	17.7	27.0			Marchesi *et al.*
Europeans	19.1	27.5	19.2	25.6	Aeby
Koreans	14.6	25.9	14.1	25.3	Lee *et al.*
Italians (both sexes)	16.1	24.8			Postacchini *et al.*
Indians (both sexes)	14.0	22.8			Ditto
Russians (both sexes)	18	21			Stefko
White Americans	17.4	26.3			Lanier
Americans	17.6	25.9	16.8	26.0	Scoles *et al.*
Americans	17.3	26.0			Berry *et al.*

Recent Americans	19.7	27.1			Panjabi *et al.*
South Africans (both sexes)	15.5	24.1			Dommisse
Caucasoid	18.0	26.0	18.0	25.0	Eisenstein
Zulu Negroid	16.0	26.0	16.0	24.0	Ditto
Sotho Negroid	16.0	25.0	16.0	24.0	Ditto
Recent Europeans (both sexes)	14.3	22			Thomson
Recent Bushmen	14	20	16	22	Ditto
Americans (?, both sexes?)	12				Magnuson (1944)
Present study (whole sample)	**16.9**	**26.2**	**16.9**	**26.0**	
Present study (modern subgroups)	**17.7**	**26.3**	**17.7**	**26.5**	

The intervertebral foramen is an anatomical structure of important clinical value. This will be outlined in depth below as a separate chapter, since it may represent a field of common scientific interest for anthropologists, anatomists and clinicianes. As already highlighted above, the osteometric assessment of this structure has its pitfalls. In the present study, the intervertebral foramen width was measured not only bilaterally, to explore any possible side difference, but also on the cranial and caudal surface of the particular vertebral body. Cinotti *et al.* (2002) conclude that the measurement of the superior and minimum intervertebral foramen width is a reliable method for the assessment of the intervertebral foramen dimensions, as it has been done for the present study. Additionally, Cinotti *et al.* (2002) state that the impact of the disc space narrowing on the foramen can be shown preferably on dried vertebra rather than wet spines, with smaller standard deviations to be found in the first ones. Therefore, by exploring the osseous intervertebral dimension, one can assume that the tendencies are similar for cadaver spine diameters and fresh wet spines too. Due to methodologic difficulties, which have been widely addressed already above, it is difficult to directly compare the intervertebral foramen values in the present study with the ones published earlier; see also Table 15.

Table 15: Intervertebral foramen width (mm) of various samples

Level / Sample	Intervertebral foramen width (males)	Intervertebral foramen width (females)	Reference
C3			
Americans (?, N males=22, N females=19)	4.5	4.3	Ebraheim *et al.* (1996)
Early 20th century Americans	5.9	6.7	Karaikovic *et al.* (1997)
C7			
Americans	4.4	4.9	Ebraheim *et al.*
Early 20th century Americans	7.0	8.4	Karaikovic *et al.*
L1			
Europeans (N males=2, N females=2)	12		Boszczyk *et al.* (2001)
Nigerians (N males=79, N females=43)	8.8	8.1	Amonoo-Kuofi (1985)
L5			
Italians (N=63, both sexes)	6.2		Postacchini *et al.* (1983)
Indians (N=58, both sexes)	5.9		Ditto
Europeans	12		Ditto
Nigerians	7.0	7.3	Amonoo-Kuofi
Americans (?, N=10, sex?)	7		Magnuson (1944)

The foramen magnum is a major anatomical landmark of the skull base. In the present study, there was no correlation between the foramen magnum size and individual stature at all, as could be seen in Table 16. Already Röthig (1971) concluded that the foramen magnum breadth is just mildly related to individual stature. A list of earlier published measurements of the foramen magnum and of the measure of the present study could be found in Table 17.

Table 16: Correlation coefficient between individual stature (femur maximum length for present study) and foramen magnum breadth

Sex	Röthig (1971)	Present study
Males	0.41 (N=560)	**0.05 (N=48)**
Females	0.35 (N=265)	**0.18 (N=43)**

Table 17: Foramen magnum dimensions (mm) of various samples, measurements according to Martin (1928)

Reference / Sample	Sagittal (*basion – opisthion*)	Transverse
Martin (1928):		
Swiss males (m)	36.1	30.5
Swiss females (f)	34.8	29.5
Elsasee m	37.1	34.3
Elsasee f	34.3	30
Romans m	35	31.6
Romans f	34	27
Tyrolese	36	29
Bavarians m	34.1	30.3
Romans f	35.2	29.8
Swiss – Wallis m	35.7	30.4
Swiss – Wallis f	34.5	28.6
Swiss - Danis	35.9	30.4
Ainos m	35.7	30.2
Ainos f	33.7	28.9
Japanese m	36.5	30.3
Japanese f	36.5	26.5
Baschkirs m	35	28.9
Telengets	36.2	29.6
Chinese	35.6	29.6
Buriats	36.8	30.4

Torguts	36.2	30.5
Malays m	34	30.3
Malays f	32.6	28.5
Australians m	35.5	29.9
Australians f	34	29.3
Paltacalos m	32.8	29.3
Paltacalos f	35.9	28.5
Nakashima (1986):		
Middle Kyushuites m	34.5	29.7
Kantoites m	35	29.8
North Kyushuites m	36.2	30.2
Yoron-islanders m	35.9	30.3
Kikai-islanders m	39.1	30.7
Shilingol-Mongolians m	37.6	30.2
Fuschen-Chinese m	35.9	30.3
Germans m	35.3	29.7
Present study:		
Whole sample m	**37.2**	**32.1**
Whole sample f	**35.8**	**30.0**
Modern subgroups m	**37.3**	**32.4**
Modern subgroups f	**35.8**	**31.0**

The spinous processes, beside their function in limiting extensional forces (White and Hirsch, 1971), serve as bony lever arms for the back musculature such as multifidus and spinalis muscles in the lumbar region, whereas the transverse processes act as levers for muscles such as longissimus, psoas major or quadratus lumborum. Both anatomical structures have only rarely been investigated so far with an osteometric perspective, this is in particular true for the spinous process (Schultz, 1961; Cotterill *et al.*, 1986). The transverse process has so far been addressed in limited reports too, all in modern samples only. Furthermore, in the present study the processes often suffered from *post mortem* damage. This resulted in overall small sample sizes, which led to the exclusion of some of these process measures from the final data analysis. All this makes it hard to validate the measured dimensions in the present study. A list of earlier published data could be found in Table 18 and 19.

Table 18: Length of spinous process as a percentage of the sagittal diameter of the vertebral body

Level - Sex	Schultz (1961)	Present study
C3 - m	98 % (N=2)	**105 % (N=37)**
C3 - f	103 % (N=2)	**90 % (N=44)**
C7 - m	214 % (N=2)	**173 % (N=72)**
C7 - f	184 % (N=2)	**167 % (N=65)**

Table 19: Transverse process width (mm) of various samples

Level / Sample	Transverse process width	Reference
C3		
Japanese – males (N=20)	56	Hasebe (1913)
White Americans (N=+/-96)	54	Lanier (1939)
White Americans – males (N=100)	54.9	Francis (1955)
White Americans – females (N=27)	50.0	Ditto
Recent Americans – both sexes (N =12)	50.3	Panjabi *et al.* (1991a)
Black Americans – males (N=100)	53.3	Ditto
Black Americans – females (N=57)	48.9	Ditto
English (?) – both sexes (N= 70)	53.5	Cyriax (1920)
Japanese – females (N=10)	50	Hasebe
Present study (whole sample) - males	**54.8**	
Present study (whole sample) - females	**50.0**	
Present study (modern subgroups) - males	**56.1**	
Present study (modern subgroups) - females	**51.9**	
C7		
Japanese - males	71.5	Hasebe
White Americans	72.5	Lanier
White Americans - males	72.4	Francis
White Americans - females	65.4	Ditto
Recent Americans (both sexes)	66.6	Panjabi *et al.*
Black Americans - males	70.2	Ditto
Black Americans - females	64.5	Ditto
English – both sexes	68.0	Cyriax
Japanese – females	68.9	Hasebe
Present study (whole sample) - males	**66.2**	
Present study (whole sample) - females	**54.6**	

Present study (modern subgroups) - males	**66.2**	
Present study (modern subgroups) - females	**52.9**	
Th1		
Japanese - males	74.8	Hasebe
White Americans	78	Lanier
English (?) – both sexes	74.7	Cyriax
Recent Americans - both sexes	75.3	Panjabi *et al.* (1991b)
Japanese – females	65.5	Hasebe
Present study (whole sample) - males	**78.0**	
Present study (whole sample) - females	**70.9**	
Present study (modern subgroups) - males	**79.1**	
Present study (modern subgroups) – females	**72.5**	
Th6		
Japanese - males	62	Hasebe
Canadians – both sexes? (N =10)	55.7	Cotterill *et al.* (1986)
White Americans	67	Lanier
Recent Americans (both sexes)	61.3	Panjabi *et al.*
English (?)	63.6	Cyriax
Japanese – females	54.1	Hasebe
Present study (whole sample) - males	**65.1**	
Present study (whole sample) - females	**59.7**	
Present study (modern subgroups) - males	**65.5**	
Present study (modern subgroups) – females	**60.9**	
Th10		
Japanese - males	56.3	Hasebe
White Americans	60.8	Lanier
Recent Americans (both sexes)	58.4	Panjabi *et al.*
English (?)	58.5	Cyriax

Japanese – females	49.4	Hasebe
Present study (whole sample) - males	**60.7**	
Present study (whole sample) - females	**55.0**	
Present study (modern subgroups) - males	**63.0**	
Present study (modern subgroups) – females	**58.1**	

L1

Japanese - males	67	Hasebe
White Americans	73.1	Lanier
Recent Americans (both sexes)	71.2	Panjabi *et al.* (1992)
English (?)	72.6	Cyriax
Japanese – females	61	Hasebe
Present study (whole sample) - males	**73.0**	
Present study (whole sample) - females	**64.6**	
Present study (modern subgroups) - males	**75.1**	
Present study (modern subgroups) – females	**68.3**	

L5

Japanese - males	88.8	Hasebe
White Americans	92.6	Lanier
Recent Americans (both sexes)	92.5	Panjabi *et al.*
English (?)	86.0	Cyriax
Japanese – females	82.4	Hasebe
Present study (whole sample) - males	**85.2**	
Present study (whole sample) - females	**78.0**	
Present study (modern subgroups) - males	**91.5**	
Present study (modern subgroups) - females	**84.5**	

Another factor to investigate while doing morphometric research is a possible intra-individual side difference. For example, no side difference could be found for the pedicle dimensions in the present study, which is consistent with most earlier reports (Marchesi *et al.*, 1988; Banta *et al.*, 1989; Xu *et al.*, 1995; Kothe *et al.*, 1996). As another exemplary measure, the vertebral body height did not show any side difference in the present study, unlike in the report by Anderson (1883), who linked the higher values of the right side of the vertebral body to the bigger weight of the internal organs on this side.

To summarize, if one compares the osteometric data of the present study of both, the whole sample as well as the selected modern samples, with earlier published measures, it can be seen that most of the measures of the present study fall within the wide range of spinal dimensions. Some exceptions are e.g., the transverse process widths at C7, which in this study are smaller than the measures published earlier. On the other hand, the pedicle dimensions at Th6 and Th10 are in this study larger than the ones published so far. Since the overall variability of the human spine, as e.g., seen in the above shown dimensions of a global sample, is quite large, these outliers of the present study may *de facto* just represent extremes of this variation or simply be caused by minor methodologic differences.

Variation of spinal morphometry due to sex and age

Both, sex and individual age are key factors contributing to the variability in osteometric measurements, as already highlighted above, and, therefore, were major issues addressed in the present study. Both factors were elaborated specifically on the two modern samples with historically known individual sex and age.

In the study presented here, males show for most vertebral measurements significantly higher values such as vertebral body height or transverse process width. In the most similar microevolutionary study of the human vertebral column, Jankauskas (1994) estimated the overall influence of sex to be about 30% - 40% of the variability of vertebral column, with age having an impact of just about 5% - 8%. Sex was a significant factor especially for transverse diameters. He reports for the cervical, thoracic and lumbar spine a significant sexual dimorphism for the vast majority of osteometric measurements, consistent with the findings of the present study. Sex was also not a major contributor towards the occurrence of spinal pathologies in the archaeologic sample examined by Jankauskas (1992). Nevertheless, males have e.g., a significantly longer thoraco-lumbar spine (Gozdziewski *et al.*, 1976). These factors, due to restriction on selected vertebral levels and non-pathologic spines, could not have been explored in the study presented here. Despite the fact that Huizinga *et al.* (1952), surprisingly, do not consider possible age and sex estimations as further factors influencing their findings on lumbar spinal canal dimensions in historic skeletons, most authors agree that sex seems to influence the spinal morphometry (Piontek, 1973; Larsen and Smith, 1980a; Larsen and Smith, 1980b; Hermann *et al.*, 1993). The results of the study presented here also support this view.

With respect to neural pathways of the spine, the results of the present study are notable. No significant sexual dimorphism can be found, basically, for the osseous outline of the neural pathways, unlike in the other spinal osteometric dimension such as e.g., the vertebral body height. This notable absence of larger neural dimensions in males has already been reported in similar way earlier (Eisenstein, 1977; Porter *et al.*,

1978b). For example, Porter *et al.* (1980) found, in an ultrasound based study, larger neural canals in females than males, especially in the subgroup of young adults. They mention a possible higher amount of epidural fat as one possible cause and the likely advantage in case of pregnancy-related mechanical stress to be responsible for this size difference. The lack of sexual dimorphism in neural canal dimensions does not mean there is no sexual difference in its shape, as earlier shown for a different prevalence of a trefoil shaped lumbar spinal canal (Eisenstein, 1980). Females show larger osseous and non-osseous spinal canal cross-section areas, but smaller neural tissue cross-section areas (Hasue *et al.*, 1983; Kikuchi *et al.*, 1984). This may make males, especially at L5 where the difference is most obvious, more vulnerable to any pathologic conditions (Hasue *et al.*, 1983). Surprisingly, there is even one dimension in the present study, which is significantly bigger in females than in males, the right caudal intervertebral foramen width on level L5. This might have clinical implications as will be discussed in depth further below. Similar findings were also reported for the intervertebral foramen and spinal nerve root dimensions (Hasue *et al.*, 1983; Kikuchi *et al.*, 1984). Additionally, Hermann *et al.* (1993) could not find a difference of the subarachnoid space in relation to sex. With regard to nerve root size, one has to be aware that females have in absolute terms the same measures, which makes them relatively to body weight even bigger than in males, as shown by Dunn (1912) for rats at least.

The particular impact of aging has been explored in the study presented here as well. Based on the modern samples with historically recorded individual age, both sexes show alterations of spinal and long bone morphology with aging. In the study presented

here, aging was found to contribute significantly *de facto* only in males. This may be due to their larger sample size, especially in the modern sample.

In the present study, the neural pathways do not change significantly with aging; this is unlike earlier reports on age-related alterations of neural osteometric dimensions. Humphreys *et al.* (1998) describe an increase of the ratio of spinal cord diameter to spinal canal diameter in the early adult asymptomatic cervical spine. They also detected an increase of the C6 / C7 foraminal width in the age group of 20 to 30 years and a slight decrease followed by another increase later for the older below the age of 50 years category, unlike the steady decrease in symptomatic patients (Humphreys *et al.*, 1998).

The osteometric dimensions unfortunately can give just a glimpse of the age-related alterations of their neural content. For example, aging leads to a decreased number of myelinated fibres and an increase in connective tissue in the spinal nerve roots (Dunn, 1912; Corbin and Gardner, 1937). However, there seems to be no change in the dorsal root / ventral root ratio with age (Corbin and Gardner, 1937), but in growing rats the increase in nerve fibres was for a longer time and more intense in the dorsal nerve root (Dunn, 1912).

Furthermore, one has to be aware that the stable dimensions of the neural pathways in the present study *de facto* represent a relative decrease of these structures with age, since other neighbouring osseous structures, such as the pedicle height, apparently increase with age. Whether this may have clinical significance as well is doubtful. Weisz and Lee (1983) found that the spinal canal reserve capacity, which is the difference between the sagittal diameters of the osseous canal and of the spinal cord, decreases with age, making the elderly apparently even more vulnerable to decreases of

the spinal canal size. Nevertheless, it is still debated e.g., if lumbar neural canal in general were becoming bigger (Clark *et al.*, 1985) or smaller (Porter *et al.*, 1980; Lee *et al.*, 1995; Tatarek, 2001) with aging and some reports could not find a clear link between spinal cord alterations and individual age (Elliott, 1945; Bailey, 1953; Legg and Gibbs, 1984). In a study by Lee *et al.* (1995) a significant influence of age on spinal morphometry, as shown for a decrease in lumbar mid-sagittal and transverse spinal canal diameters, occurred only after the age of 60 years. Therefore, this factor due to the average low mean age in archaeologic samples may not be that relevant. The average age in the historically recorded modern samples is in the present study even below 50 years.

In the present study, the found age-related trends of spinal morphometry, significant after Bonferroni's correction only in males, are some pedicle heights and sagittal and transverse vertebral body diameters. The last one is consistent with earlier reports (Jankauskas, 1992; Jankauskas, 1994), explained as a possible effect of degenerative changes (Jankauskas, 1994), but a decrease of anterior vertebral body height with age (Jankauskas, 1992) could not be found in the present study.

The increase of the vertebral body and pedicle diameters with individual age in the present study seems to be due to a general increase in robusticity in the elderly, a remodelling resulting in a surplus deposition of bone, which most likely does not affect the osseous outline of the neural pathways. The robusticity generally changes with age, most prominent for the measurements of the long bone shafts, as reported in the literature (Pfeiffer, 1980) and possibly as a physiological reaction to compensate for loss of stiffness due to a general decrease in bone mass, especially in women (Pfeiffer,

1980). In the present study, the long bones, as tested for the modern age-recorded samples, showed for males such an increase in robusticity, by expressing an increase in circumference but no significant change in length, but for females, only femur length decreased significantly.

Inter-populational variations of spinal morphometry

The inter-populational variations of spinal morphometry, as already highlighted by various authors (Wetzel, 1910; Hasebe, 1913; Thomson, 1913; McCotter, 1916; Willis, 1923; Stefko, 1926; Martin, 1928; Stewart, 1932; Lassek and Rasmussen, 1938; Matiegka, 1938; Wood-Jones, 1938; Lanier, 1939; Francis, 1955; Bornstein and Peterson, 1966; Piontek and Budzynska, 1972; Ericksen, 1976; Eisenstein, 1977; Eisenstein, 1980; Tibbetts, 1981; Postacchini *et al.*, 1983; Amonoo-Kuofi, 1985; Nakashima, 1986; Ross *et al.*, 1991; Jason and Taylor, 1995; Lee *et al.*, 1995; Tatarek, 2001) will hardly apply in the present study, since all selected samples belong to a Central-Western European group. Nevertheless, the more modern the European samples are, the more likely decreased the inter-group morphological variability, at least as shown for cranial characters (Henneberg *et al.*, 1978). Whether this is the case for the spinal morphometry as well would also be worth to be further investigated.

Relation of geography and society to spinal morphometry

Various environmental factors influence the morphometry of the human body. For example, the geographic latitude alters the expression of selected morphological traits in humans, such as bi-iliac breadth (Ruff, 1994) or the lateral internal thoracic

artery (Surtees *et al.*, 1989a; Surtees *et al.*, 1989b; Henneberg, 1992). In the present study, all individuals come from similar geographic latitudes, approximately 45° N - 49° N. This should rule out major influences of latitude on the spinal morphometry. Furthermore, the unique situation of the more alpine populations in Switzerland, as for example of the Chur sample, has already been highlighted above.

From a cultural point of view, the samples presented here reflect various historic transition periods, from prehistoric hunting and gathering populations, such as Upper Paleolithic, to a more sedentary agricultural dispersed life-style, such as Neolithic and Bronze Age, semi-urban and urban societies in Medieval times and, finally, post-industrialization communities.

The influence of changes in European life style and its effect on human growth, morphological characteristics, morbidity and mortality has been studied in numerous reports (Henneberg *et al.*, 1978; Lewis, 2002). In general, two major morphologically distinguishable groups are known for the European Holocene; a Southern-Western European population type and Northern-Eastern series (Schwidetzky, 1967; Schwidetzky, 1972; Schwidetzky and Rösing, 1976; Rösing and Schwidetzky, 1977; Rösing and Schwidetzky, 1981; Schwidetzky and Rösing, 1984; Schwidetzky and Rösing, 1989). The geographical distribution and the inter-populational difference decreased during most time periods (Schwidetzky, 1967; Schwidetzky, 1972). For some dates regional differences became more apparent towards more modern times and Rösing and Schwidetzky (1981) name increased social differentiation in the form of religious or urban *versus* rural locations as possible factors. Furthermore, a remarkable closer similarity of the population subtypes within the Western samples than for the

Eastern series has been described (Rösing and Schwidetzky, 1977; Schwidetzky and Rösing, 1989). This is of interest since the selected series of this work, with the single exception of the Hainburg material, would most likely belong to the Western population clusters and small inter-populational differences help to analyse the various groups.

The vast majority of the selected individuals in this work originate from inland non-coastal ecozones. The only exception would be the French Mesolithic individuals. Changes in Upper Paleolithic to Mesolithic in Europe have been of socio-cultural and ecological nature, with an increased population density, with a decrease in nomadic lifestyle, an increased resource reliability and food abundance but also an increased technological sophistication, all factors contributing to an ecological framework relying on the interaction between resource-stress and humans (Hayden, 1981).

Body and especially limb morphology seem to be influenced by various factors such as gene flow, transmitted by a population movement from Sub-Saharan Africa towards Europe - and which resulted in altered metabolic demands and vasomotoric adaptation to a cold environment - or, finally, stress due to physical activity (Trinkaus, 1981; Holliday, 1996; Holliday, 1997; Holliday, 1999). The importance of these factors for the spinal column morphology in particular cannot conclusively be said at this stage. At least it is well known, that limb proportions changed in Europe from a more Sub-Saharan African type in Early Upper Paleolithic to a more modern European body shape in the Late Upper Paleolithic (Trinkaus, 1981; Holliday, 1996; Holliday, 1997; Holliday, 1999). Mathers and Henneberg (1996) suggested a changing of relative trunk size and lower limb proportions to be represented in the found different trends for hominid body height and weight within the last 4 millions of years. Since they found no such divergence of trends in *Homo sapiens* body weight and height for the last 32,000

years, they propose possible different microevolutionary trend acting in this time frame, which would be of particular interest for the present study; such microevolutionary trends will be elaborated separately further below.

The impact of physically demanding life-style on the vertebral column must be taken into account as well. The decrease in robusticity during such historic transition periods was most likely related to adaptations to physically less demanding life-style (Larsen, 1980; Larsen, 1981; Larsen, 1982). Nevertheless, one interpretation by Schwidetzky (1962) arguing that specific character and behavioural patterns, possibly linked with level of gracilisation, could have been selective in such changing environment, seems to stretch the case.

Another physical factor, the age of commencement of adult physical activities has so far been supported to a variable extent as an etiological factor of bone robusticity alterations (Bridges, 1993; Knüsel, 1993). Apparently, some agricultural societies show a higher bone robusticity but a lower prevalence of degenerative bone disease than their hunter-gatherer counterpart as a result of juvenile onset of heavy labour in the first life-style group (Knüsel, 1993). The early physical involvement of young members in a settled society would allow these individuals to have a higher skeletal robusticity and plasticity later in life and, therefore, less likely to be vulnerable to degenerative osseous alterations (Knüsel, 1993). This seems in particular reasonable for the morphometry of the vertebral column.

Not only the selection of a clinical or historic spinal sample, but also its geographical, environmental and ethnic background contributes to alterations in spinal morphology; therefore, normative data for spinal morphometrics are always applicable to a certain degree for a confined geographical area only (Ross *et al.*, 1991; Hermann *et*

al., 1993). This is most likely also true for the present study. Further bio-socio-archaeological studies on the examined samples would reveal a deeper insight into their particular cultural situation, which are crucial to better assess its particular impact on the spinal osteometric values.

Influence of stature and body size on spinal morphometry

If one investigates microevolutionary and secular trend of the spinal column, its individual dependence on stature needs to be assed as well. It is well known that the particular spinal morphology and length is a function of individual stature (Dwight, 1894; Hasebe, 1913; Fully and Pineau, 1960; Gozdziewski *et al.*, 1976; Gallagher *et al.*, 1988; Minne *et al.*, 1988). A correlation between individual vertebral body height or pedicle height and stature has been described earlier (Fully and Pineau, 1960; Tibbetts, 1981; Gallagher *et al.*, 1988; Scoles *et al.*, 1988). Similar findings can be reported for the study presented here.

In the present study, most of the vertebral body height and main diameters in both sexes correlated with individual femur length; see also appendix 9. In males, selected transverse process widths and pedicle heights show such a significant correlation as well, whereas in females, selected intervertebral foramen dimensions and pedicle heights do.

To assess individual stature from spinal dimensions some of the earlier studies propose for accurate individual stature estimation an equation consisting of lower limb long bones such as femur or tibia and parts of the spine such as the lumbar region in case of just partial skeletal preservation (Fully and Pineau, 1960; Tibbetts, 1981).

Unfortunately, the reconstruction of trunk size and individual size based on partially preserved vertebral columns has never fully been explored, at least not for historic skeletal samples. Therefore, to assess in the present study individual stature based on the selected vertebrae measured does not seem to be reasonable.

With respect to a possible link between stature and size of spinal neural pathways, one has to remember that various parts of the spinal cord may be differently related to overall body size (MacLarnon, 1996b), or even unrelated (Elliott, 1945). This clouds the interpretation of altered osteometric measurements, even by taking body size into account in data analysis. In the present study, only spinal canal transverse diameter at C3 in both sexes correlated significantly with femur length. Earlier reports on a possible link between spinal cord size and individual stature or weight give an equivocal picture of such a morphometric relationship. Furthermore, as already discussed above, the size of the osseous spinal canal can only give a rough insight into its neural content anyway. It is still not apparent, how the spinal cord area is a function of the quantity of somatic afferent and efferent nerve fibres (Fox and Wilczynski, 1986). Furthermore, it is unlikely but theoretically possible, that the dimensions of the nerve fibres such as density and length may vary as a function of altered body size (Fox and Wilczynski, 1986). Apparently, spinal cord cross section dimensions, showing on selected levels high degree of inter-individual variability, and individual body weight do not correlate (Elliott, 1945). Additionally, just a tendency but no clear correlation between spinal cord length and individual stature or vertebral column length is known (McCotter, 1916). It is still debated if spinal cord cross-sectional areas or spinal cord weight correlate with body size in a surface to volume way (Fox and Wilczynski, 1986; MacLarnon, 1996b), since it may be rather linked to the somatic innervation of the body

surface. Since spinal cord weight, according to MacLarnon (1996b), does scale less with body weight than brain weight, earlier evolutionary explanations taking metabolic paradigm on changing brain size into account (Martin, 1981) may not apply in the case of the spinal cord. Furthermore, simple ratios such as brain size/spinal cord size will not be independent of body size (MacLarnon, 1996b). Finally, to test any correlation of spinal morphology and individual body weight one has to be aware that the accurate methodical reconstructing of the latter from individual height, especially in fossil material, is still debated (Henneberg *et al.*, 1989). To summarize, based on the results of the present study and on the above outlined equivocal earlier reports, one should be careful in linking osseous dimensions of spinal neural pathways to individual stature or weight. Any such relationship, especially of its neural content, would most possibly not be of simple linear association and different from the known ones of other major neural parts such as e.g., the skull and brain size.

Microevolutionary trends in body size and robusticity

Microevolutionary trends in body size, skeletal robusticity and neural tissue size may reflect on the osteometric spinal dimensions in humans, since bone remodels depending on the demanding normal and abnormal forces acting on it (Wolff, 1892). Furthermore, an alteration in living conditions, either of cultural or environmental background, may be reflected through adaptive mechanisms in the human skeleton. It is, therefore, crucial to be aware of these trends as far as relevant for the selected samples and time spans.

During hominid evolution body size increased from Pliocene to Late Pleistocene (Frayer, 1984; De Miguel and Henneberg, 1999) and decreased in the Holocene, at least

in Europe (Frayer, 1980; Frayer, 1981; Frayer, 1984; Jacobs, 1985b). Alterations, such as the reduction in masticatory and gastrointestinal tract as well as in the musculoskeletal system interfered with the supposed body shape changes (Henneberg, 2001a).

The natural selection of body size is influenced by long-term genetics, such as constant mutations, genetic interbreeding or gene pool drifts, and in short-term more by direct environmental factors. Frayer (1984) postulates smaller bodies being energetically more economical and, therefore, been naturally selected in times of lack of ressources. Gracilisation seems to be created by technological improvement during human evolution. Smaller bodies are more fit in terms of food efficiency under conditions of decreased demands for physical strength and robusticity (Frayer, 1981; Henneberg and Steyn, 1995).

Human skeletal morphology reflects its genetic and environemental influences, as already discussed above. The skeletal robusticity alterations seem to be rather dependent on long-term and repetitive mechanical forces, whereas degenerative changes more likely seem to be related to traumatic or intense but rare impacts (Bridges, 1991). The question, therefore, remains at least partially unsolved how far changes in life-style, as seen from a hunter-gatherer society towards an agricultural community, influence bone morphology or what other factors contribute as well.

Human postcranial robusticity is undergoing various changes (Ruff *et al.*, 1993; Trinkaus, 1997). Alterations in biomechanical loading, hormonal or genetic adaptations control bone remodelling especially of the diaphyseal bone (Ruff *et al.*, 1993; Trinkaus *et al.*, 1994; Trinkaus, 1997). The humerus is an excellent long bone to show any

plasticity, because the humerus does not show any impact from locomotion and systematic influences such as nutrition will appear symmetrically (Trinkaus *et al.*, 1994; Trinkaus, 1997). In the present study, the humeral changes are found to be consistent, in males and females, with the femoral ones.

Gracilisation occurred as described above in Europe, Australia and East Asia (Brown, 1992), whereas in Africa and certain regions of Australia its extent is still debated (Henneberg and Steyn, 1993; Pretty *et al.*, 1998). The extent and precise pattern of the European gracilisation is still debated, as widely outlined above. The general trend in decrease of robusticity, apparent from the Late Paleolithic to more modern times (Formicola and Giannecchini, 1999), is at least in some of the selected individuals originating from Central Europe not observable. Whereas the gracile Téviec-island type individuals, among others all of the selected Hoëdic and Téviec samples, in general follow the trend of postcranial gracilisation and decrease in individual stature, the more robust Téviec-continental types, among others the Gramat individual in the samples of the present study, do this to a lesser extent (Vallois and de Félice, 1977).

In general, the selected samples for the present study may not be representative enough to highlight in particular the microevolutionary alterations of long bone morphology, since this was not the main issue of this work. Tables 21 –24 list earlier reported humerus lengths, femur lengths femur head breadth, femur mid-shaft circumference and bi-iliac width, whereas Table 25 lists estimated statures of various historic European samples. A summary of these values could be found in Figures 22 - 25. Figure 26 shows the means of the measured long bones in the present study.

Table 20: Maximum humeral length (mm) of various samples

Sample	Humeral length	Reference
European Upper Paleolithic – males (N=19)	337	Jacobs (1985b)
European Upper Paleolithic – females (N= 13)	304	Ditto
European Upper Paleolithic – males (N=14)	342	Frayer (1981)
European Upper Paleolithic – females (N=8)	308	Ditto
European Neandertals (N=9, both sexes)	307	Trinkaus (1981)
European Early Upper Paleolithic (N=15, both sexes)	341	Ditto
European Late Upper Paleolithic (N=10, both sexes)	305	Ditto
European Mesolithic (N=41, both sexes?)	298	Various sources, cited by Trinkaus
European Mesolithic – males (N=20)	317	Jacobs
European Mesolithic – females (N=11)	290	Ditto
European Mesolithic – males (N=11)	312	Frayer
European Mesolithic – females (N=9)	285	Ditto
Pre-agricultural Americans (1000 BC – 1150 AD) – males (N=14)	324	Larsen (1981)
Pre-agricultural Americans (1000 BC – 1150 AD) - females (N=25)	306	Ditto
Agricultural Americans (after 1150 AD) – males (N=42)	317	Ditto
Agricultural Americans (after 1150 AD)- females (N=52)	293	Ditto
Euro-Americans (N=39)	319	Trinkaus *et al.* (1994)
Euro-Americans (N=40) - males	326	Trinkaus
Euro-Americans (N=40) - females	302	Ditto
White Americans (N=63) - males	336	Trotter and Gleser (1952)
White Americans - females	304	Ditto

Table 21: Femur length (mm) and femur head breadth (mm) of various samples

Sample	Femur length - males	Femur length – females	Femur head breadth	Reference
Early Upper Paleolithic, modern *H. sapiens* (N=11, both sexes)	461		48.1	Ruff (1994)
La Chapelle-aux-Saints (m)	433			Ditto
Predmosti (m)	455			Ditto
European Neandertals (N=5, both sexes)	434		51.7	Ditto
Late Upper Paleolithic, modern *H. sapiens* (N=4, both sexes)	434		46.7	Ditto
European Upper Paleolithic (N males=17, N females=5)	471	422		Frayer (1981)
European Mesolithic (N males=20, N females= 17)	444	409		Jacobs (1985b)
European Mesolithic (N males=16, N females=13)	435	404		Frayer (1981)
Pre-agricultural Americans (1000 BC-1150 AD) (N males=9, 14; N females=19, 31)	449	434	45.5 (m) / 41.1 (f)	Larsen (1981)
Agricultural Americans (after 1150 AD) (N males=47, 58; N females=54,61)	448	416	43.8 (m) / 39.0 (f)	Ditto
American Whites (N males=255, N females=63)	473	430		Trotter and Gleser (1952)

Table 22: Femur mid-shaft circumference (mm) of various European samples (Jacobs, 1985b)

Sample	Femur circumference
Upper Paleolithic – males (N=16)	93
Upper Paleolithic – females (N=8)	78
Mesolithic – males (N=16)	94
Mesolithic – females (N=15)	80

Table 23: Bi-iliac breadth (mm) of various European samples

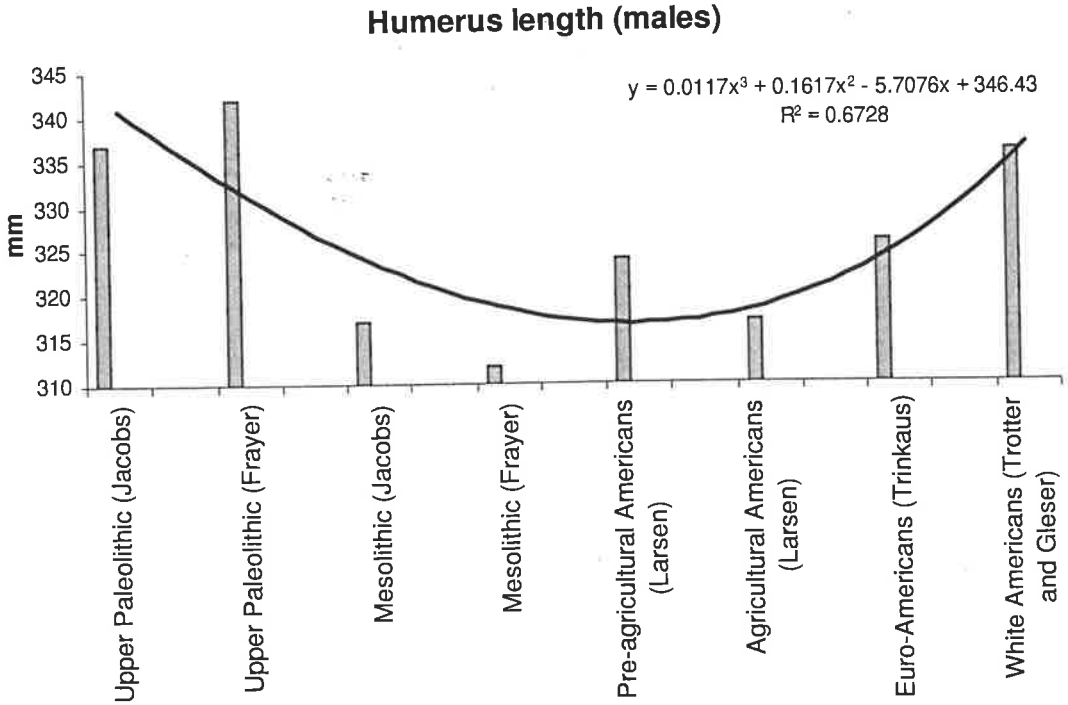
Sample	Bi-iliac breadth	Reference
La Chapelle-aux-Saints (male)	295	Ruff (1994)
Predmosti (sex?)	268	Ditto
Lithuanians (1st Millennium AD, males)	281	Jankauskas (1994)
Lithuanians (1st Millennium AD, females)	267	Ditto
Lithuanians (2nd Millennium AD-rural, males)	262	Ditto
Lithuanians (2nd Millennium AD - rural, females)	262	Ditto
Lithuanians (2nd Millennium AD - urban, males)	263	Ditto
Lithuanians (2nd Millennium AD – urban, females)	260	Ditto
Europeans (males)	279	Martin (1928)
Europeans (females)	266	Ditto

Table 24: Estimated statures (cm) of various European samples

Sample	Stature	Reference
Neandertals (N males=4)	163	Various studies, cited by Martin (1928)
La Chapelle-aux-Saints (N male=1)	164	Ruff (1994)
Mean male archaic *Homo sapiens*	167	Ditto
Mean male early modern *Homo sapiens*	177	Ditto
Upper Paleolithic (N males=20)	174	Frayer (1984)
Upper Paleolithic (N females=9)	159	Ditto
Italian Upper Paleolithic (N males= 12)	164-178	Formicola (1983)
Italian Upper Paleolithic (N females=3)	153-168	Ditto
Early Upper Paleolithic (N males=10)	174	Frayer (1981)
Early Upper Paleolithic (N females=5)	161	Ditto
Late Upper Paleolithic (N males=10)	174	Ditto
Late Upper Paleolithic (N females=4)	157	Ditto
Late Paleolithic - Veyrier (N male=1)	169	Pittard and Sauter
Mesolithic (N males=26)	165	Ditto
Mesolithic (N females=15)	154	Ditto
Italian Mesolithic (N males=10)	162-172	Formicola
Italian Mesolithic (N females=4)	150-151	Ditto
Late Upper Paleolithic (Central Europe, N males=7)	166	Formicola and Giannecchini (1999)
Late Upper Paleolithic (Central Europe, N females=7)	155	Ditto
Mesolithic - Téviec (N males=7)	159-162	Pittard and Sauter (1945)
Mesolithic - Téviec / Hoëdic (N males=10)	161	Formicola and Giannecchini
Mesolithic - Téviec / Hoëdic (N females=12)	151	Ditto
Mesolithic - Gramat (N male=1?)	165-166	Ditto
Mesolithic - Birsmatten (N male=1)	160	Sedlmeier and Kaufmann (1996)
Mesolithic (Western Europe, N males=96)	163	Formicola and Giannecchini

Mesolithic (Western Europe, N females=72)	151	Ditto
Mesolithic (N males=41)	168	Frayer (1984)
Mesolithic (N females=26)	156	Ditto
Mesolithic (N females= 5)	153	Formicola and Franceschi
Neolithic (N males=62)	166	Frayer (1984)
Neolithic (N females=46)	154	Ditto
Neolithic – Italy (N males=24)	162	Formicola
Neolithic – Italy (N females=17)	151	Ditto
Neolithic - France and Belgium (N males=127)	163	Pittard and Sauter
Neolithic - France and Belgium (N females=53)	151	Ditto
Eneolithic / Bronze Age –Italian (N males=14)	164	Formicola
Eneolithic / Bronze Age –Italian (N females=14)	153	Ditto
Pompeiians - 79 A.D. (N males=127)	163-169	Henneberg and Henneberg (2002)
Pompeiians - 79 A.D. (N females=145)	152-156	Ditto
Bajuwars – 400-800 A.D. (both sexes)	171-173	Various studies, cited by Wurm (1982)
Francs - 500-800 A.D. (N males=47)	166	Pittard and Sauter
Francs - 500-800 A.D. (N females=16)	152	Ditto
Francs – 400-900 A.D. (both sexes)	171-173	Various studies, cited by Wurm
Alemanns – 400-800 A.D. (both sexes)	170-174	Various studies, cited by Wurm
Alemanns – 400-800 A.D. (Swiss, both sexes)	172	Ditto
Alemanns – Swiss (N males=750)	169	Pittard and Sauter
Alemanns – Swiss (N females=455)	158	Ditto
Alemanns – Swiss, 700 –1200 A.D. (both sexes)	165-170	Ditto
French - 900-1100 A.D. (N males=140)	166	Pittard and Sauter
French - 900-1100 A.D. (N females=46)	156	Ditto
French, Medieval Ages (N males=294)	166	Ditto
French, Medieval Ages (N females=101)	156	Ditto
Medieval (N males=41)	169	Frayer (1984)
Medieval (N females=46)	156	Ditto

Southern Germans, 1180-1400 A.D.	166-168	Various authors, cited by Wurm
Rural Polish, 1200-1400 A.D. (males)	172	Henneberg *et al.* (1984b)
Rural Polish, 1200-1400 A.D. (females)	159	Ditto
Rural Polish, 1400-1600 A.D. (males)	170	Ditto
Rural Polish, 1400-1600 A.D. (females)	161	Ditto
Rural Polish, 1600-1700 A.D. (males)	171	Ditto
Rural Polish, 1600-1700 A.D. (females)	160	Ditto
Rural Polish, 1700-1900 A.D. (males)	171	Ditto
Swiss conscripts, 1500-1650 A.D.	164-168	Various authors, cited by Wurm
Lithuanians, 1st Millennium A.D. (N males=24)	174	Jankauskas (1994)
Lithuanians, 1st Millennium A.D. (N females=16)	161	Ditto
Rural Lithuanians, 2nd Millennium A.D. (N males= 62)	168	Ditto
Rural Lithuanians, 2nd Millennium A.D. (N females=29)	157	Ditto
Urban Lithuanians, 2nd Millennium A.D. (N males=205)	167	Ditto
Urban Lithuanians, 2nd Millennium A.D. (N females=180)	156	Ditto
Modern (females)	170	Frayer (1984), with data from Eveleth and Tanner (1976)
Modern (males)	174	Ditto
Modern South Africans of European extraction (males)	179	Henneberg and van den Berg (1990)
Modern South Africans of European extraction (females)	165	Ditto



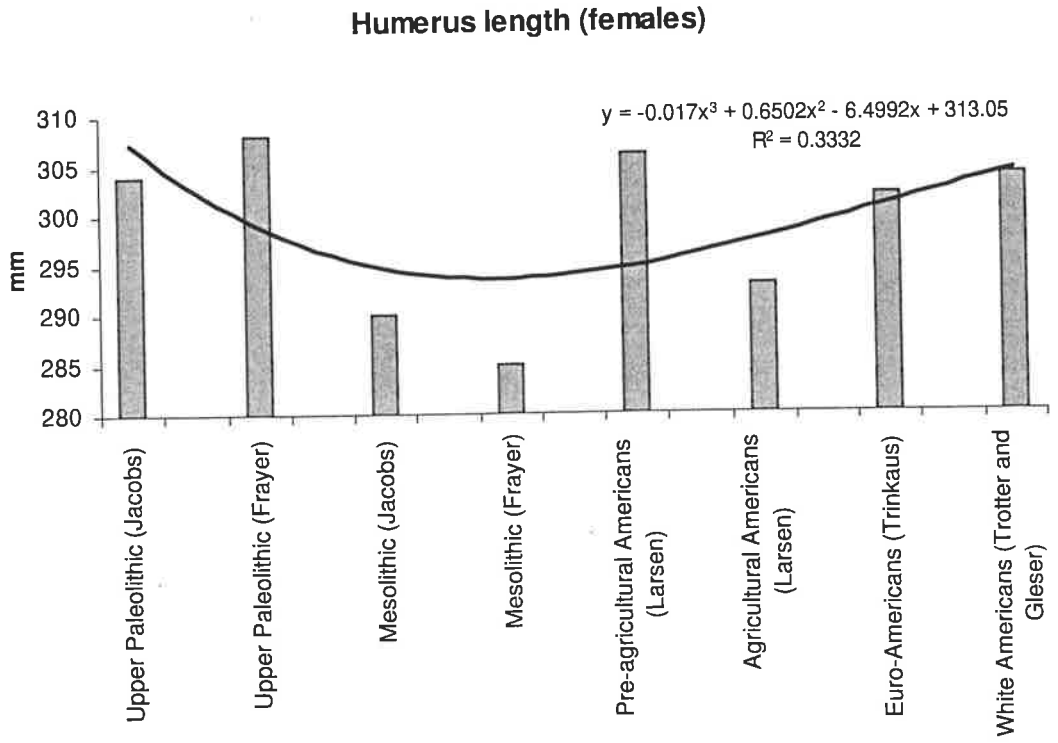
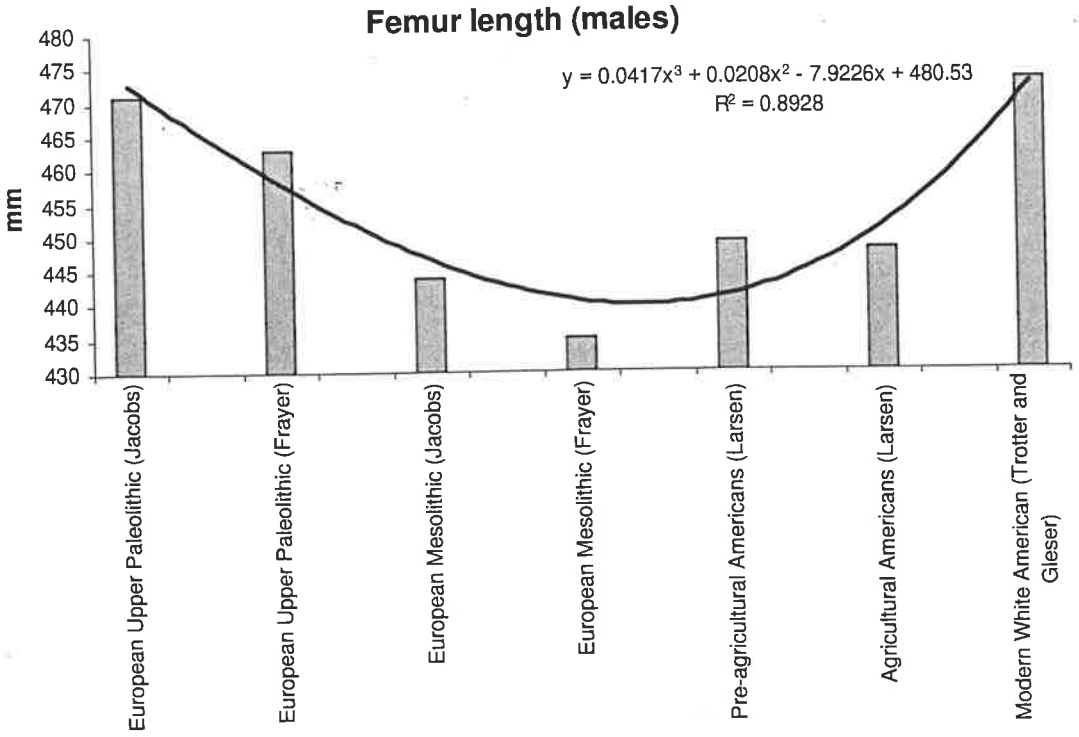


Figure 22: Mean humerus length of various historic and modern samples, for complete reference see Table 20.



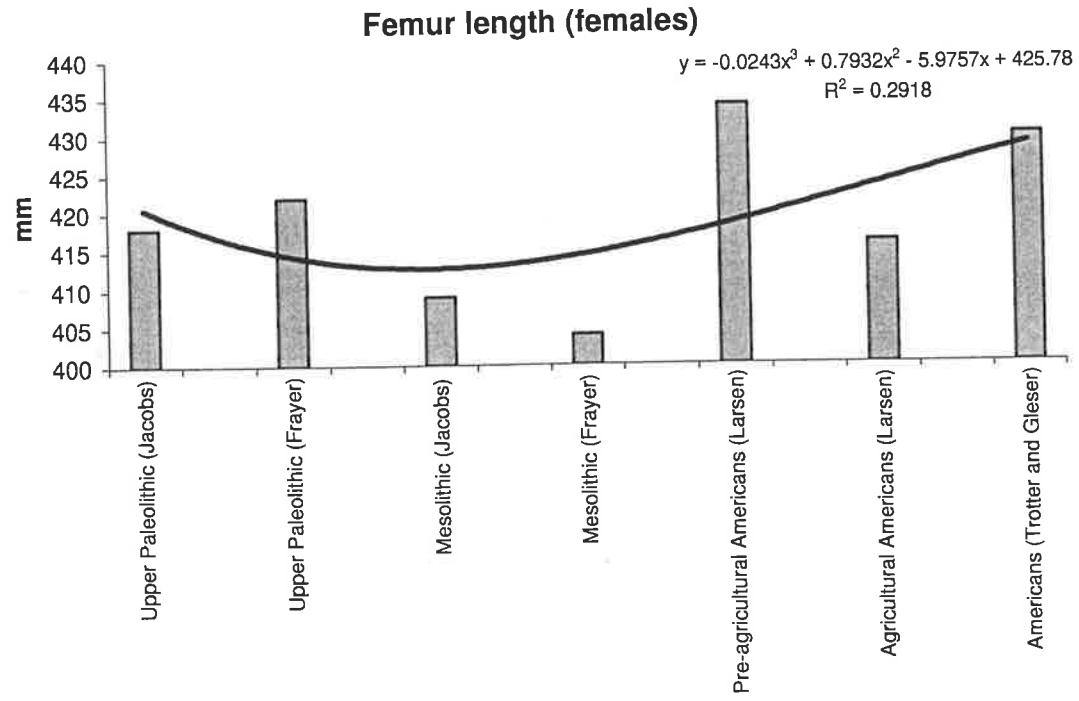


Figure 23: Mean femur length of various historic and modern samples, for complete reference see Table 21.

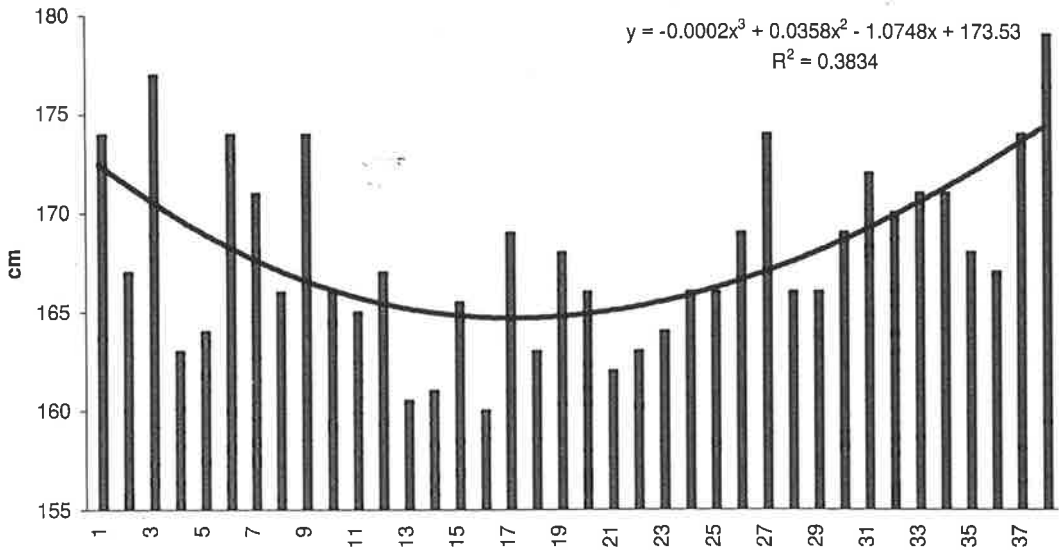


Figure 24: Estimated male statures of various historic and modern samples, for complete references see Table 24.

1) Early Upper Paleolithic

2) Mean male archaic *Homo sapiens*

3) Mean male early modern *Homo sapiens*

4) Neandertals

5) La Chapelle-aux-Saints

6) Upper Paleolithic

7) Italian Upper Paleolithic

8) Late Upper Paleolithic

9) Late Upper Paleolithic

10) Late Upper Paleolithic

11) Mesolithic

12) Italian Mesolithic

13) Téviec

14) Téviec / Hoëdic

15) Gramat

16) Birsmatten

17) Veyrier

18) Mesolithic

19) Mesolithic

20) Neolithic

21) Neolithic – Italy

22) Neolithic - France and Belgium

23) Eneolithic / Bronze Age –Italian

24) Pompeiians – 79 A.D.

25) Francs - 500-800 A.D.

26) Alemanns – Swiss

27) Lithuanians, 1st Millennium A.D.

28) French - 900-1100 A.D.

29) French - Medieval Ages

30) Medieval

31) Rural Polish 1200-1400 A.D.

32) Rural Polish 1400-1600 A.D.

33) Rural Polish 1600-1700 A.D.

34) Rural Polish 1700-1900 A.D.

35) Rural Lithuanians, 2nd Millennium A.D.

36) Urban Lithuanians, 2nd Millennium A.D.

37) Modern

38) Modern South Africans of European extraction

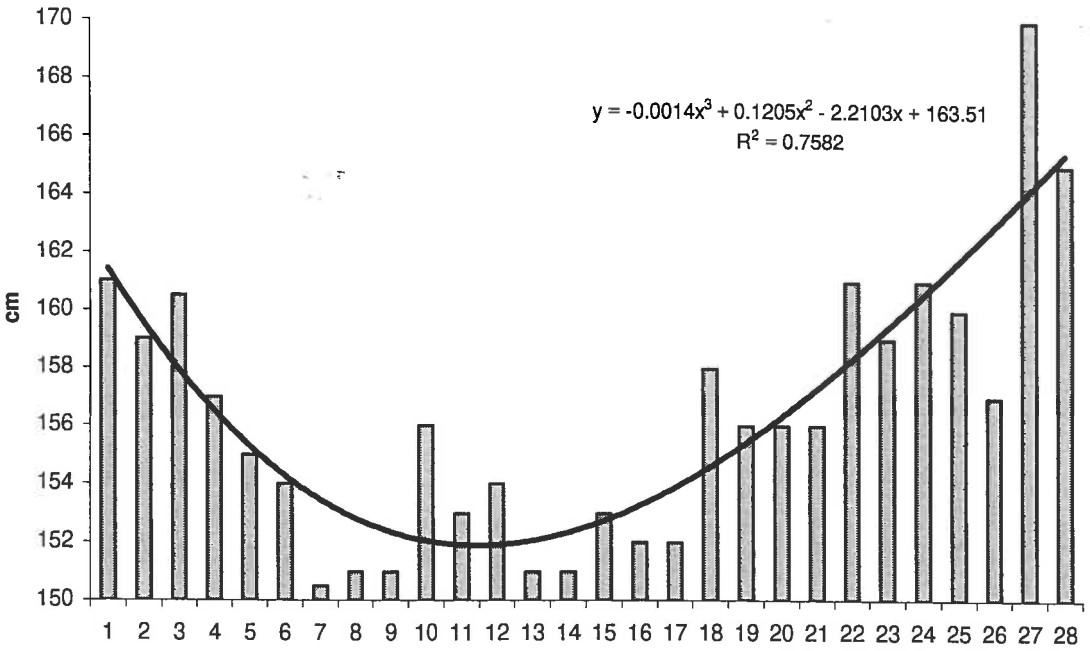


Figure 25: Estimated female statures of various historic and modern samples, for complete references see Table 24.

1) Early Upper Paleolithic
2) Upper Paleolithic
3) Italian Upper Paleolithic
4) Late Upper Paleolithic
5) Late Upper Paleolithic
6) Mesolithic
7) Italian Mesolithic
8) Téviec / Hoëdic
9) Mesolithic
10) Mesolithic
11) Mesolithic
12) Neolithic
13) Neolithic – Italy
14) Neolithic - France and Belgium
15) Eneolithic / Bronze Age – Italian
16) Pompeiians – 79 A.D.
17) Francs - 500-800 A.D.
18) Alemanns – Swiss
19) French - 900-1100 A.D.
20) French, Medieval Ages
21) Medieval
22) Lithuanians, 1st Millennium A.D.
23) Rural Polish 1200-1400 A.D.
24) Rural Polish 1400-1600 A.D.
25) Rural Polish 1600-1700 A.D.
26) Rural Lithuanians, 2nd Millennium A.D.
27) Modern
28) Modern South Africans of European extraction

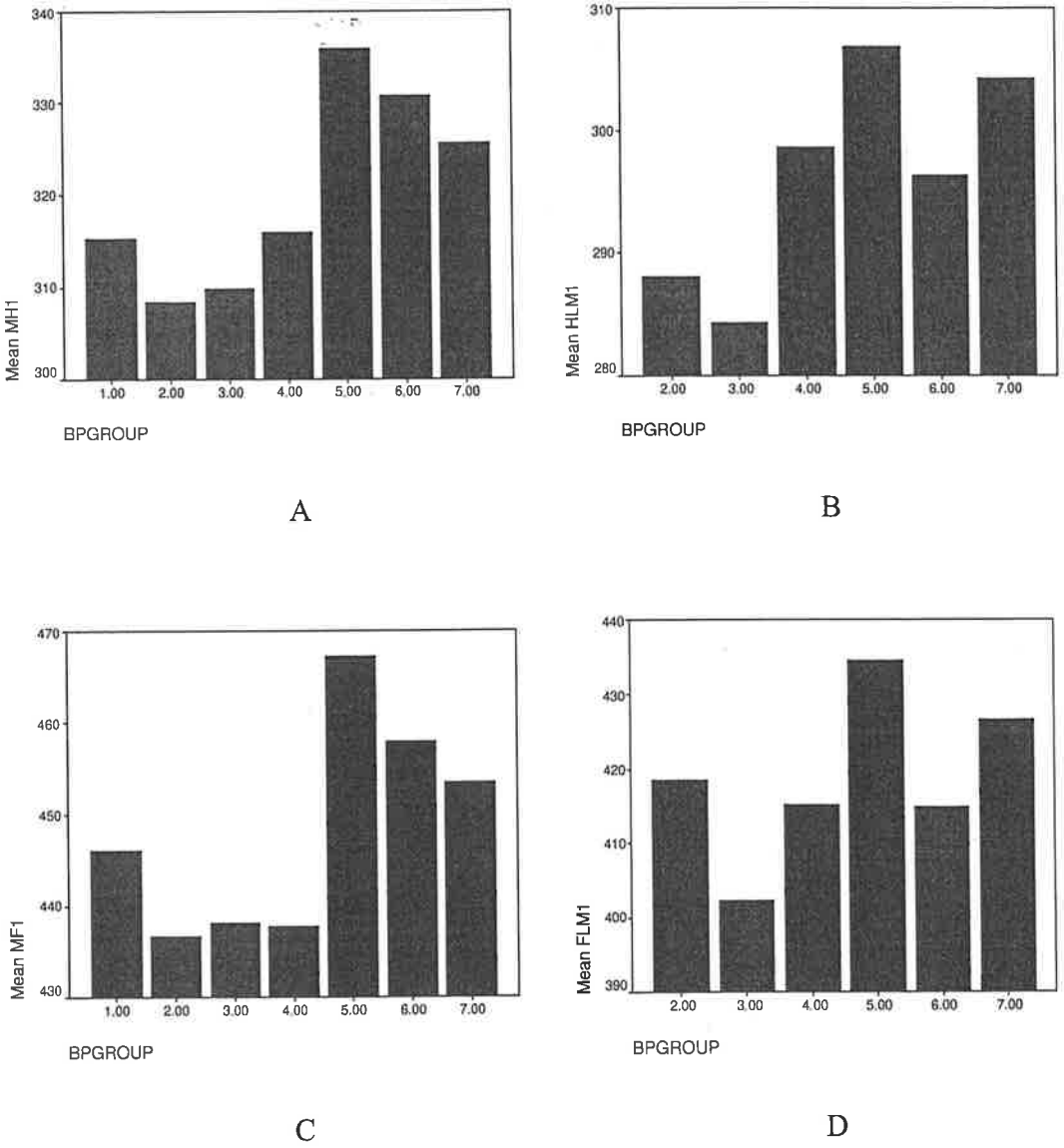


Figure 26: Means of measured long bones by time periods in the present study (1=Paleolithic, 2=Mesolithic, 3=Neolithic, 4=Bronze Age, 5=Early Medieval, 6=Late Medieval, 7=Modern)

A) Humerus length (males), B) Humerus length (females)
C) Femur length (males), D) Femur length (females)

In the samples presented here, the femur length changed differently for both sexes. Males show in general a significant secular increase, whereas females express a decrease with time. In males, also an increase in bi-iliac width and arm dimensions could be found. The femur length decreased from the Paleolithic to Mesolithic from 446 mm to 437 mm, with subsequently stable means until the Late Medieval samples with 467 mm. The two last modern samples show again a slightly smaller male femur length of 458 mm and 453 mm respectively. In general, femur circumference altered slightly less than femur length. In females, femur length decreased from the Mesolithic (419 mm) to the Bronze Age with an increase to the Late Medieval Ages from 402 mm up to 435 mm, and another decrease for the two most modern samples. Limits for femur size (Martin Nr 2) are supposed to be between 340 mm and 536 mm, with a sex difference of 44 mm in Swiss Alemanns and in German samples 46 mm, with in general a remarkable variability (Martin and Saller, 1957). The absolute humerus length varies from 260 mm to 380 mm, also with a notable sex difference (Martin and Saller, 1957). In the present study, femur and humerus length, as measured, fall within these reported limits.

Apparently, the samples of the present study exhibit different patterns for males and females, but in general, it can be seen, based on the limited sample, that there is a decrease in stature from the Paleolithic to the Bronze Age and a subsequent increase with astonishingly high values for the medieval sample, especially if one compares with the selected earlier reports on femur dimensions and statures of historic populations.

How far the samples in the present study are part of a uniform historic European trend has to be addressed too. No regional difference have been reported for the Early Upper Paleolithic, before the Last Glacial maximum, whereas in the Late Upper Paleolithic till the Pleistocene-Holocene transition, there was apparently a noticeable

demarcation between Western and Eastern European samples (Formicola and Giannecchini, 1999). From a cultural point of view the Upper Paleolithic should not be regarded as a simple uniform pan-European period (Straus, 1995). In terms of skeletal records, this may be different. However, a conclusion, based on the samples included in this study, cannot be reached. The limitation in the current sample to Central and Western European origin avoids some possible problems, though the findings will be only applicable to the Western European region. Nevertheless, there is an obvious need of further studies to focus on a possible inter-regional difference of the spinal morphology. No major intra-regional differences in stature within the Western European Late Upper Paleolithic and Mesolithic samples have been reported, with in general lower stature values for the Western group than for their Eastern European counterparts (Formicola and Giannecchini, 1999). The large stature of the Early Upper Paleolithic Europeans could be explained by various factors (Formicola and Giannecchini, 1999). Funerary behaviour could indicate a bias towards socially higher and possibly male individuals (Frayer, 1981), but this seems to be rather unlikely.

Climatic adaptations reflected in the found high values of the Early Upper Paleolithic individuals, as also found in the present study, are even more controversial. According to the ecologic-adaptive rules by Bergmann (1847) and Allen (1877), stating that individuals living in cold climate have on average shorter limbs in relation to their trunk and have larger body mass, the Ice Age maximum would favour more bulky individuals. For example, the Neandertals seem to be on the average 10 cm shorter, but 3.5 kg heavier than their early anatomically modern human counterparts (Ruff, 1994), which has been interpreted as a left-over of ancient climatic condition (Formicola and Giannecchini, 1999). Some interpret the alterations of European body shape and limb

proportions, in particular since the Early Upper Paleolithic, as being related to environmental and genetical influences (Trinkaus, 1981; Holliday, 1997; Holliday, 1999), while others argue that the importance of the climate for the morphologic alterations described for the European Paleolithic-Mesolithic transitions period to be of lesser significance (Frayer, 1981). Nevertheless, in this study all samples come from a temperate Central European climate and from similar latitude, as already outlined above, so climatic changes would have been most likely similar for the various samples and of known Central-Western European type.

Evolution of hunting technique, such as the use of spears and, later most likely in Mesolithic times, of the bow, together with the disappearance of the megafauna, could have had an impact of body morphology, such as skeletal robusticity and individual stature from the Late Pleistocene onwards. The increased hunter-game killing distance by using more developed techniques lowers apparently the human need for high robusticity and long upper limbs (Frayer, 1981). Furthermore, the particular importance of the prey size on the development of sexual dimorphism in terms of individual stature has been mentioned as well (Frayer, 1980).

Changes in nutrition, such as decreased protein intake due to increased population density, and natural selection favouring longer limbs could be additional interfering factors (Wurm, 1982; Formicola and Giannecchini, 1999). The possible particular nutritional situation of the selected samples in the present study, mostly from Southern Germany and Switzerland has already been addressed above, based on the important study on the impact of the protein intake on human morphology (Wurm, 1982). Nutritional influences were also controversially discussed as possible etiologies of human morphology by various authors (Frayer, 1981; Larsen, 1981; Trinkaus, 1981).

Formicola and Giannecchini (1999) link the apparent stature transformation in the Late Paleolithic mainly to low protein diet and inbreeding effects resulting from denser settlement. Mesolithic individuals were most likely less subject to nutritional stress, such as protein-calorie resources (Frayer, 1981), and, therefore, should not be selected to be smaller as found in the data. Some explain the low femur length sexual dimorphism in the Late Würm period as a condition linked to higher nutritional stress, which favours reduced sexual dimorphism due to higher vulnerability of the males to such hardship (Jacobs, 1985b). Furthermore, the high female robusticity in the Late Würm period is proposed to be a result of increased musculo-skeletal stress (Jacobs, 1985b).

Sexual dimorphism is a reflection of human social behaviour in terms of physical activities. In the present study, the sexual dimorphism with regard to the postcranial non-spinal measurements was significant, with males having all values bigger than females. Only bi-iliac width showed no significant sexual dimorphism in the examined samples. In general the sexual dimorphism was approximately 7% for the femur length and even higher for the femur circumference with approximately 11%, both being quite big in comparison to the mentioned earlier reports. Surprisingly, no relationship between skeletal robusticity changes and sexual dimorphism in various European time periods exists (Frayer, 1980; Frayer, 1984). Also there is a reported in general a decrease in sexual dimorphism, in terms of stature, from the Late Upper Paleolithic till the Neolithic and afterwards no change at all, unlike the increase in the individual stature for the same time span (Frayer, 1980). This shows that the degree of sexual dimorphism is apparently independent of overall body size. Beside the general cultural changes, sex specific modifications may be explained by adaptations of labour

duties between males and females. Changes in physical stress will be due to new repetitive tasks, such as planting and harvesting instead of hunting food, which have, if applied even only intermittently for a short daily time, a higher impact in general on bone mass that just statical forces (Lanyon and Rubin, 1984). Biomechanically this labour may be physically more demanding explaining the sometimes-found higher skeletal robusticity in settled human societies.

Additional environmental factors such as migration patterns as well as changes in infectious disease load and its possibly linked nutritional status influence cloud the interpretation of the bony picture as well (Trinkaus, 1981; Jacobs, 1985a; Ruff, 1994; Holliday, 1996; Holliday, 1997). Furthermore, subclinical microtrauma leading in the long term to degenerative joint disease will be barely visible initially in the skeletal records.

To summarize, the well-known decrease in skeletal robusticity and individual stature in the European Paleolithic-Mesolithic transition period to be rather a result of selective forces favouring smaller bodies with reduced metabolic demands and of the weapon sophistication, no longer favouring taller body stature and bony robusticity, than climate or nutritional stress (Frayer, 1981). The decrease of postcranial diaphyseal robusticity as seen in early modern *Homo* as well as in living humans was supposed to be due to a decrease of mechanical loading (Ruff *et al.*, 1993; Trinkaus, 1997). These findings could be linked to varying susceptibility of the different long bone parts in different periods of ontogeny, such as adolescence *versus* adulthood (Ruff *et al.*, 1994). Whether these assumptions on the importance of environmental factors are also true for the spinal morphometry would be crucial to know and would need further evaluation.

Alterations of brain and skull morphometry as models for the spinal microevolution

If one discusses changes of spinal morphometry, it is necessary to be aware of evolutionary trends acting on the other major part of the human nervous system, the brain, too. At least for the brain size such trends have been widely explored.

The evolution of the brain size is supposed to differ from the one of the spinal cord (MacLarnon, 1996a). Relative to body size spinal cord size varies less than brain size in living species (MacLarnon, 1996b). Since the Late Pleistocene human brain size seems to have decreased by approximately 10% (Wiercinski, 1979; Henneberg, 1988; Henneberg and Steyn, 1993; Ruff *et al.*, 1997). This reduction of absolute brain size over the past 35,000 years appears to be paralleled by a decrease in average body size (Ruff *et al.*, 1997). It is assumed that brain size in mammals is a representation of metabolic rate and not primarily body surface area (Martin, 1981). Brain size may be related to lean body mass and body height rather than to body weight (Holloway, 1980), which includes in humans to a highly variable degree the metabolically mostly inert fat tissue (Henneberg, 1998). How close the relation between metabolic rate and brain size or neural tissue size in general might be, could be questioned, since its relation seems to be much more diverse than just a representative of a trade off between gut and brain (Henneberg, 1998). Nevertheless, the human brain / body size ratio is postulated to be induced by structural and functional reduction of the gastrointestinal tract (Aiello and Wheeler, 1995) or as a "structural reduction" of the musculo-skeletal support, respectively (Henneberg, 1995). A total of approximately 40% of the gastrointestinal and masticatory complex size seem to be lost as a secondary adaptation, which, to summarize, can be linked to changes in overall body size of about one third (Aiello and

Wheeler, 1995; Henneberg, 1998). The gut size reduction appears to be related to richer meat-based diets and improved extra-oral food processing, which is supported by increased mental abilities. Since brain size correlates well with muscle mass (Rogers, 1992), the brain size decrease in the Holocene with its structural body alterations does not surprise. Brain size and intelligence or mental capacity are weakly or not correlated at all (Willerman *et al.*, 1991; Henneberg, 1992), therefore, the brain size reduction may be based more on structural reorganization and increase of neuronal efficiency than just represent a loss of neuron numbers. The decrease in brain size, with miniaturization of its neuronal cells, has been explained to be a result of ecosenitive influences in a form of a decreased meat consumption, not a general decrease in nutritional supply (Wiercinski, 1979). In general, the alterations of brain size in recent human evolution show the plasticity of the central nervous system in humans and, therefore, raise expectations of similar trends for the size of the vertebral column.

In general, the size of neural structures might not reflect in a simple evolutionary way its function and, in particular, the extent of its demand. For example, it is still debated, if humans, due to the increased demand for motor control and bipedialism, require greater mass of motor cells and, therefore, show larger neural canal dimensions than their extant hominoid relatives (Sanders, 1991). In rats, there is apparently a link between the size of the innervated tissue and the calibre of the cervical nerve roots (Dunn, 1912). Furthermore, one has to be aware that the number of somatic afferent and efferent nerves must not correlate with the body surface area (Fox and Wilczynski, 1986). Differences in various sensory modality systems or density of body surface innervation, depending on body size, may account at least partially for such inconsistencies (Fox and Wilczynski, 1986). In addition, Agduhr (1917) already found

an increase in size of these parts of the spinal cord, which were object of forced training, as shown for growing cats.

The increase of brachycephalisation, another example of microevolution in humans, has been found in Central Europe to be much more common nowadays than it was in earlier times (Henneberg, 1976); however, not all areas in the world show such an ongoing brachycephalisation trend (Henneberg and Steyn, 1993; Kouchi, 2000). As one possible interpretation of the selective pressure acting on skull form, a differential morbidity of brachycephalic individuals caused by childhood diseases has been mentioned earlier (Henneberg, 1976; Henneberg *et al.*, 1984a). As outlined above, there are some links between spinal morphometry and the occurrence of pathologies, such as lower back pain, but its evolutionary impact appears doubtful. Additionally, climatic influences such as temperature and humidity ecozones have been linked to head form (Beals, 1972), following the rules of Allen (1877) and Bergmann (1847). In general, this would most likely affect the spinal morphology as well. Finally, nutritional effects (Lasker, 1946; Wiercinski, 1979; Moishezon-Blank, 1992), migration patterns, parental environmental background or genetic influences, such as exogamy or endogamy, the latter interacting with age and social factors, might reflect on the head shape (Palsson and Schwidetzky, 1973; Billy, 1975; Kobylinasky, 1983). Again, it seems reasonable to assume that these factors have at least a partial impact on the evolving spinal morphometry as well.

Microevolution and secular trends of the spine and their possible etiologies

Evolutionary forces can be either of directional or more random-like, non-directional type (Wright, 1968). The first one is usually caused by mutations or natural

selection, whereas the second one generally is influenced by factors such as migration or inbreeding. Both main evolutionary forces may alter the human spinal column. In the present study, the overall changes of life-style and environment seem to suggest a relaxation of natural selection, a phenomenon already proposed in earlier studies (Henneberg, 1976; Henneberg *et al.*, 1978; Stephan and Henneberg, 2001). The second main evolutionary force could be in the present work migration patterns involving large parts of central Europe during the covered time span. How far each of the two main forces contributes to the above-presented alterations of human spinal morphometry is difficult to assess at this stage. More comparative data would be crucial to improve any conclusive judgement.

In the present study, various alterations of the spinal morphology with time were found, which can be classified as microevolutionary or secular trends. A range of variables changes significantly with historic time period either in linear, cubic, quadratic, exponential, logarithmic or power function forms. Most of the diameters show an increase towards more modern times, while some e.g., female femur length, showed a decrease through time. As shown in Figures 19 and 20, there are in both sexes consistent alterations of mean values, but there are also changes in standard deviations of various parts of the spinal column.

The changes in mean, as well as in standard deviations, represent two ways of relaxation of selective forces. The shift of means in any direction is a representation of a microevolutionary or secular trend, in the present study presented generally by increasing values. Therefore, this would be a positive directional selection, similar to the above-discussed example of trends towards brachycephalisation in Europe. The change in standard deviations reflects an alteration of the overall variability. Since most of the

changes in standard deviations show an increase as well, this indicates that the diversity of the spinal column increased between the Neolithic / Bronze Age samples and the modern ones in the present study. Again, this part would be a disruptive, non-stabilising relaxation of natural selection. Non-stabilising forces will support the expression of diversity and lead to a higher variability of specific morphological traits.

So far, few reports have addressed secular and microevolutionary trends in the human spine. Jankauskas (1994) found no significant influence of secular factor on anatomical spinal landmarks, except for the middle vertebral body breadth of cervical vertebrae. However, Stefko (1926) described a decrease in spinal height in Russian samples from "before 1912" and "from 1923 to 1928", which might reflect the historic influence of starvation. Additionally, Tatarek (2001) reported briefly significant variation of the lumbar neural canal in relation to ancestry of the sample as well as in relation to geographic origin. Furthermore, Minne *et al.* (1988) highlighted the impact of a secular increase in stature in the last century on the spinal morphometry. By comparing the comparative data of Minne *et al.* (1988), one sees that there may be a slight secular trend since the end of the 19th century; see also Figure 27. Nevertheless, one has to be aware that the represented samples have different methodical origin, being either cadaveric and osteometric or radiological clinical studies; this may bias the reported trend.

If one analyses the few historic reports on spinal morphometry available, which are comparable in terms of measurements with the present study, one finds equivocal results. No consistent and clear secular trend is e.g., visible in the L5 ventral vertebral body height in the two sexes; see also Figure 28. While in females there seem to be an

overall increase with time, no such trend can be found in males. The samples might be too dispersed in historic and geographic terms to be comparable. Additionally, inter-observer errors apply. Furthermore, as shown above, individual stature is at least partially reflected in the spinal measures.

In the present study, a large number of variables correlate with individual stature and show microevolutionary or secular trends. To exclude the influence of stature in these trends, the variables should be divided by femur length, assuming a linear dependence on each other. After doing so, and after Bonferroni's correction for multiple comparisons, some vertebral dimensions in the present study still show a significant trend through time, as could be seen in appendix 13; selected variables are also shown in Figures 29 and 30. Furthermore, one could e.g., test a possible independence of the vertebral dimensions at C7, the neural level that innervates part of the upper limb, from humeral robusticity. No variable at C7 expressed after Bonferroni's correction a significant microevolutionary trend independent of humeral robusticity; see also appendix 13.

To summarize, in the present study selected vertebral dimensions show a significant microevolutionary increase, with one case of a significant decrease, independent of any femur length alterations. Unfortunately, only by having historical and recent vertebral data of earlier studies with listed individual femur length, which is not the case, one could draw a bigger picture of microevolutionary and secular trends of the human spine.

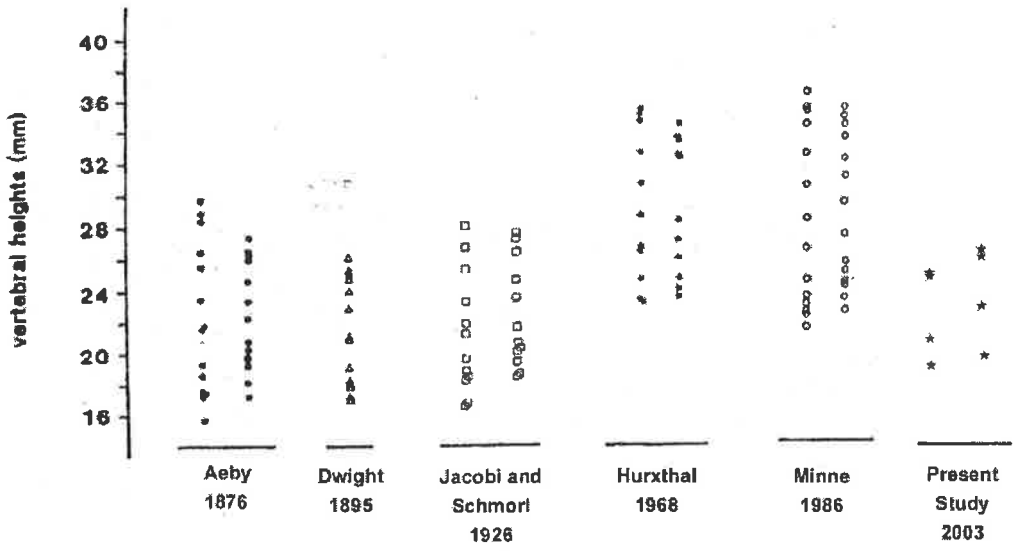


Figure 27: Secular trends of male and female spinal dimensions, with vertebrae Th4 - L5 included for earlier studies and Th6 / Th10 / L1 / L5 in the present study (Figure modified after Minne *et al.* (1988), for listed references see there. The data by Hurxthal and Minne are obtained from radiological measurements, with all others resulting from osteometric studies).

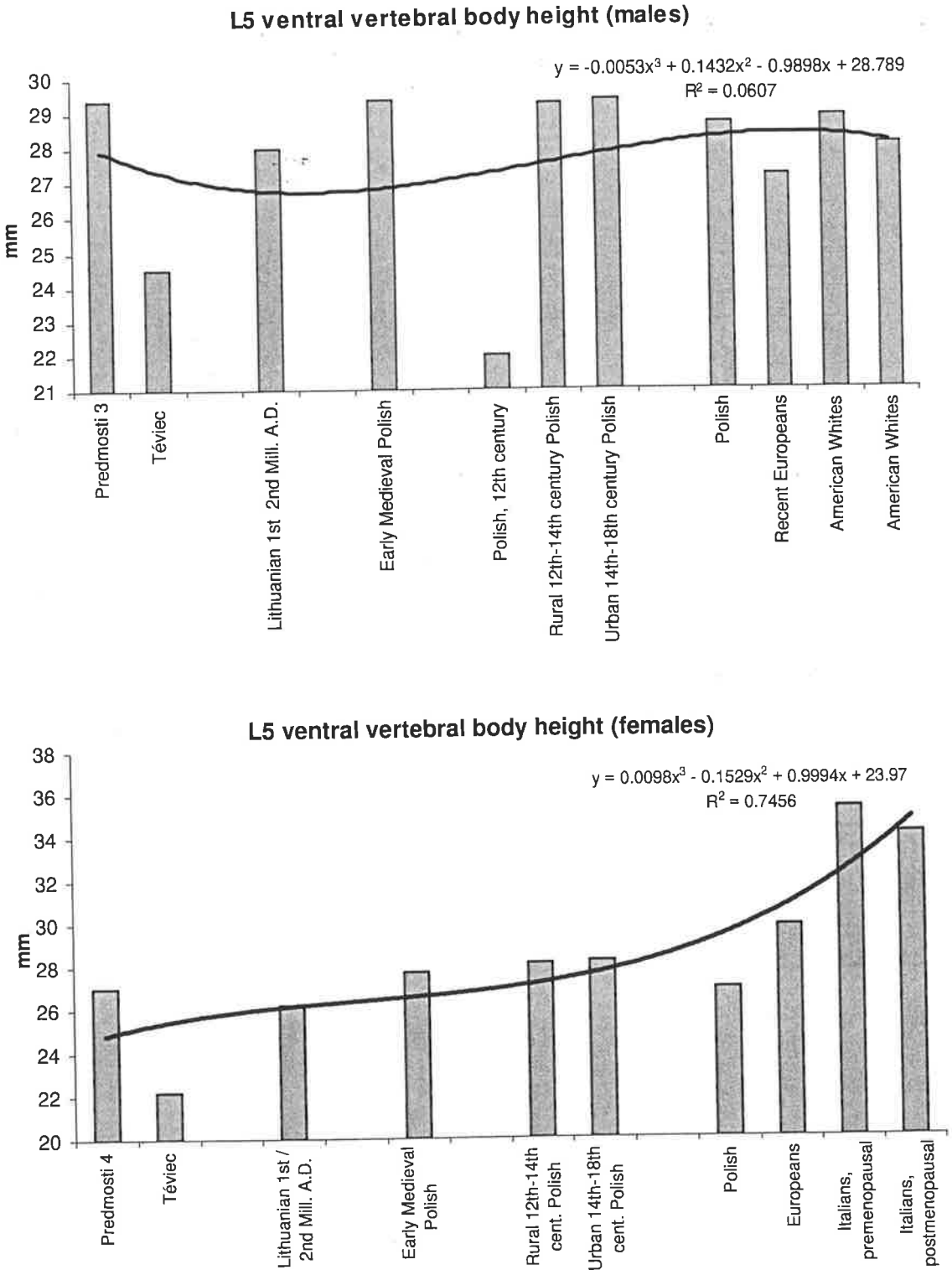
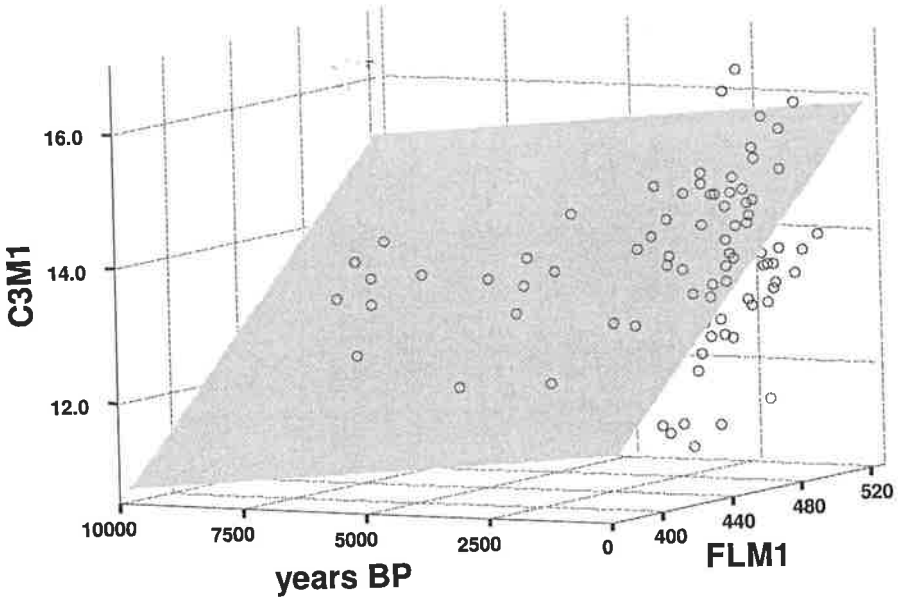


Figure 28: Microevolutionary trends of selected vertebral measurements, based on reference samples listed in Table 11.



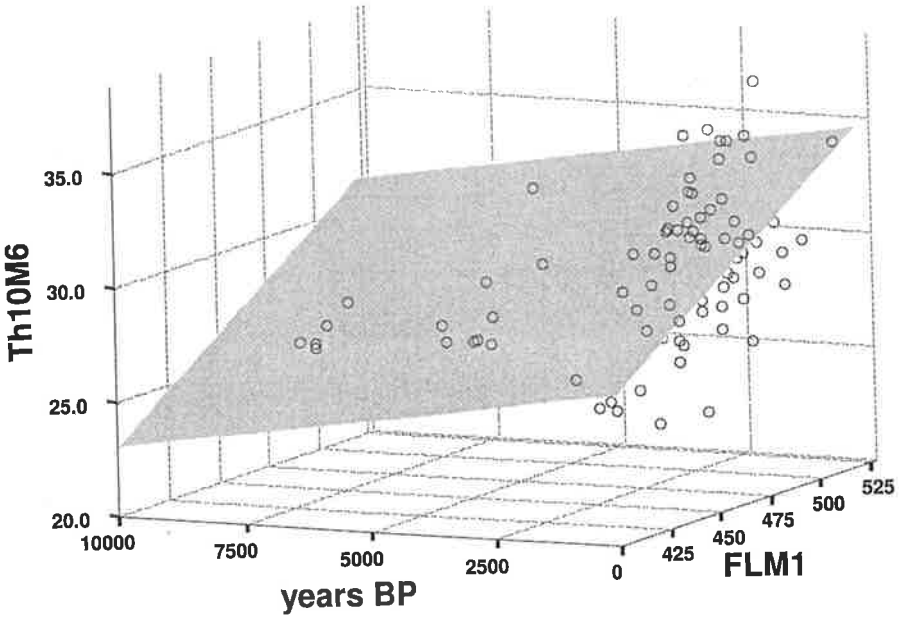


Figure 29: Selected variables in males with significant alterations (whole sample; $p < 0.05$; after Bonferroni's correction for multiple comparisons) with time before present (years BP) and independent of maximum femur length (FLM1): C3 ventral vertebral body height (C3M1) and Th 10 sagittal body transverse diameter (Th10M6) shown with linear regression plane.

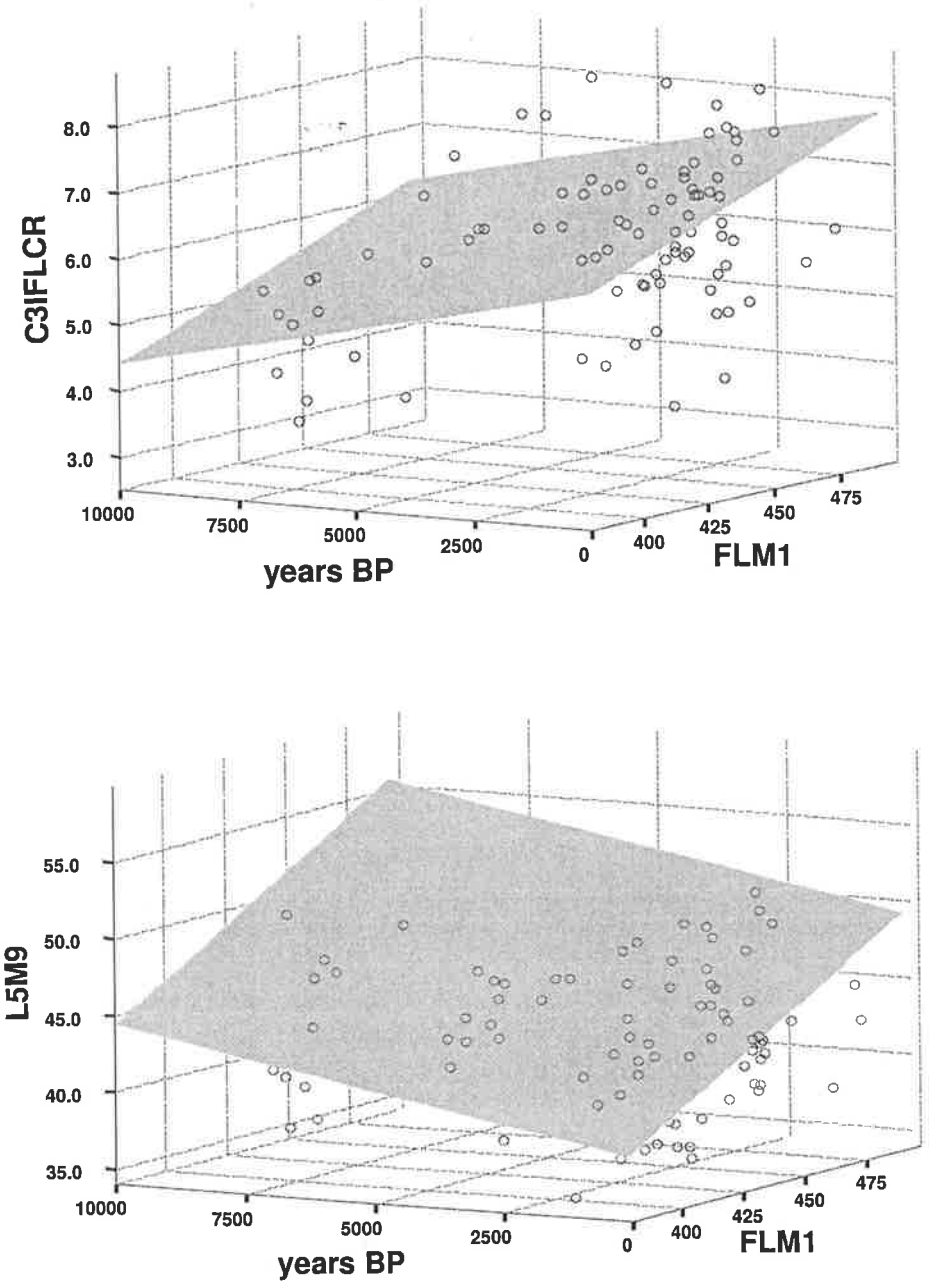


Figure 30: Selected variables in females with significant alterations (whole sample; $p < 0.05$; after Bonferroni's correction for multiple comparisons) with time before present (years BP) and independent of maximum femur length (FLM1): C3 left cranial intervertebral foramen width (C3IFLCR) and L5 vertebral body transverse diameter (L5M9) shown with linear regression plane.

The human body is influenced by a continuously changing environment and tries to adapt to an energetic optimum. At the same time, these alterations have an impact on the environment. This self-amplifying feedback between humans during evolution and their living conditions (Bielicki, 1969) will certainly affect the human spinal morphometry. Environment, social organization, technology and human biological characteristics form a self-amplifying feedback regulator system through human evolution as well as in microevolutionary and secular adaptations. As mentioned above, any alterations of natural selection influence the variability of human morphological traits (Henneberg *et al.*, 1978). Various "cultural" and "non-cultural" mechanisms act in such a positive ecological framework (Bielicki, 1969).

In general, natural selection acts through differential mortality and morbidity as expressed by various levels of reproductive success, all of them hard to be replicable in terms of specific spinal morphometry. Modifications in gene pools are usually slower than adaptations to a changing environment. The latter one can be of various forms, as the example of the coincidence of introduction of a feudal social system in Poland and the spread of brachycephalisation shows (Henneberg, 1976). It seems worth to be further investigated whether similar socio-cultural events would explain spinal osteometric alterations.

Possible etiologies of secular and microevolutionary trends could be of various origin: Decrease of premature mortality, birth-planning masking natural fertility, improved prenatal care, early childhood vaccination programs, improved medical technology, psychosomatic stresses, physical activity, changes from nomadic to settled ways of life, dietary changes - such as decreased protein consumption or the influence of modern nutrition additives - greater mobility of people and, therefore, higher exchange

of less related gene pools, climate, and alterations of growth rate or socio-economic status have been mentioned so far (Lasker, 1946; Beals, 1972; Palsson and Schwidetzky, 1973; Billy, 1975; Wiercinski, 1979; Bielicki and Welon, 1982; Wurm, 1982; Kobylinasky, 1983; Jacobs, 1985a; Henneberg, 1992; Moishezon-Blank, 1992; Ruff, 1994; Henneberg and George, 1995; Henneberg and Steyn, 1995; Henneberg, 1997; Trinkaus, 1997; Henneberg and Louw, 1998; Hukuda *et al.*, 2000; Kouchi, 2000). As one anecdotal example, even the influence of changes in baby sleeping positions as a possible factor of microevolutionary trends of cranial shape has been discussed, but ruled out as etiological factor (Kouchi, 2000). Nevertheless, it would be worth to be further investigated how a change in subadult behaviour actually influences adult spinal morphology.

Furthermore, one spinal variation, the incidence of spina bifida occulta in various historical and geographical samples (Henneberg and Henneberg, 1999), could be explained by several factors such as the level of fluoride in the drinking water (Gupta *et al.*, 1995), variation between so called civilized *versus* non-civilized populations (Post, 1966), better living conditions, improved diet and vitamin B6 and B12 supplementation (Elmazar *et al.*, 1992) or by interbreeding and genetic isolation (Macchiarelli, 1989). Another anatomical variant of the spine, the occurrence of a foramen transversarium bi-partitum, shows a secular increase mostly between the Late Roman Period and the Medieval Ages (Susa and Varga, 1981). Furthermore, Porter and Pavitt (1987) showed a possible influence of juvenile stress on the spinal canal dimension, based on two archaeologic samples. Their study is of high value, because it is a rare attempt to link historic environmental factors, possibly even acting *in utero,*

with clinically relevant alterations of the spinal morphology. Some of the factors influencing the occurrence of spinal variants could be important for the alteration of the non-pathologic spinal morphology as well.

Hormonal influence on microevolutionary trends, such as decreased skull size, has been postulated earlier (Henneberg and Steyn, 1995). A change in a few or even just in one allele is needed to alter significantly a hormone, its receptors or its physiological response. Clinical syndromes such as e.g., achondroplasia, which involve the skeletal morphology, depend on just a single point mutation. Any alteration of hormonal levels and activities during human evolution seems to be quite likely (Rühli and Henneberg, 2002). Hormones and similar acting substances under genetic or environmental control have an important influence on growth and functional adaptation of a whole variety of human tissues. Earlier reports already postulated a hormonal-based microevolution of a cranial variation as well as possible microevolution of a selected part of the postcranial skeleton (Rühli and Henneberg, 2001; Rühli and Henneberg, 2002; Rühli *et al.*, 2003), therefore, this seems quite likely for the vertebral column too.

Nutritional factors have already been related to secular and microevolutionary trends in humans (Frayer, 1984). A low animal- / high vegetable-protein diet and rice eating was proposed as possible etiology for the altered prevalence of cervical spine pathologies in historic Japanese samples, rather than genetic or repetitive mechanical factors in form of the traditional salutative bowing (Hukuda *et al.*, 2000). The general intake of proteins, but also alterations in baby feeding practices in form of shortened breast feeding time and early onset of artificial protein rich diet, were related to changes in individual stature in various historic time periods in Germany (Wurm, 1982). Milk

protein seems to have the biggest impact on skeletal growth, with animal protein and vegetable protein being of less importance (Wurm, 1982). At last the high stature of the Medieval samples in the present study could be related to the specific nutritional conditions in the samples origin.

Various authors addressed the fact that changes in lifestyle such as the transition from a hunter-gatherer to a more settled agriculturalist way of life cause adaptations in the postcranial skeleton morphometry (Larsen, 1980; Larsen, 1981; Larsen, 1982; Bridges, 1989), as already discussed above. Apparently, it is more likely that decreased mechanical load rather than reduced protein intake has caused the changes in postcranial skeletal dimensions (Larsen, 1981). Beside socio-cultural and technological ecological changes, a climatic shift from a Pre-Würm maximum towards the present Inter-Glacial state has been mentioned too (Jacobs, 1985b). The short-term stature alterations seem to be rather linked to nutritional influences, whereas long-term effects as for example changes in body breadth, expressed by bi-iliac breadth, may be genetic adaptations to influences such as climate (Ruff, 1994). For example, this could explain some of the differences found in body proportions in Europe between Neandertals and modern *Homo sapiens*. Genetic drift and gene flow, due to the lack of genetic group isolation for the first phenomenon and due to continuous population migration in early European history, has been ruled out for the found alterations in stature, cranial shape, tooth size and general robusticity (Frayer, 1984). Furthermore, due to the parallel decrease in tooth size and tooth variation, "relaxed natural selection" has not been regarded as accountable for these trends, but rather directional selection has been proposed to be responsible (Frayer, 1984). However, both, natural selection and the "probable mutation effect" were suggested to cause the human dental changes (Brace, 1963; Calcagno and

Gibson, 1988). The true genetic factors causing such alterations are not known; this is in particular factual for the spinal morphometry.

Furthermore, the morphometry of the human spine may be altered by various factors such as degenerative changes, aging or injuries and diseases. In an unaffected vertebral column, as selected in the present study, these factors would not be relevant, except for the normal age-related influences, as discussed above.

As another etiology, a difference in life style between males and females was suggested to be at least partially responsible for secular changes, as seen in selected parts of the postcranium (Rühli *et al.*, 2003). Such a difference in life style between males and females would most likely influence the spinal morphology too. To summarize, as already Frayer (1984) admitted, the underlying factors of the altered human morphological characteristics are difficult to explore.

Additionally, it is difficult to point out how specific factors influence various body elements, as can be seen exemplified by the selective impact of poor socio-economic conditions in children (Henneberg *et al.*, 1998). Apparently, the general living environment finds a different response on various parts of the human body, with the trunk length, as a representation of the vertebral column in the living, usually to be less dependent on these specific conditions than other body parts, such as the long bones (Henneberg *et al.*, 1998).

The influence of environmental stress on the spinal morphology has been highlighted earlier (Porter and Pavitt, 1987). Again, the precise acting factors and the most vulnerable period of the human spine growth are unknown, but possibly an early involvement of stress factors on the human spine development results in later higher risk

of clinical conditions (Porter and Pavitt, 1987). The importance of growth disruption on adult spinal canal dimensions is well known (Clark *et al.*, 1985). It is notable that most of the canal dimensions of the human spine are acquired intrauterine, which makes them more vulnerable to influencing factors at this early stage of individual development (Clark *et al.*, 1985). However, the lumbar spine, for example, shows a greater variability after birth than the other parts of the human vertebral column (Schultz, 1961). Therefore, any microevolution of an environmental factor will interfere with the vertebral column growth to various extents at different times of an individual's life.

The various factors influencing human spinal growth must be taken into account too (Roaf, 1960), since at least some of them may also be relevant in the present study. One can differentiate between intrinsic and extrinsic factors, such as infectious or hormonal influences (Roaf, 1960). For most spinal disorders, it is not well known which of the altered osseous or soft tissue factors actually is of primary and which is of secondary nature, and the various elements of the human spine have an independent growth pattern interacting with each other (Roaf, 1960). One can now assume that misbalance acting even on just one of these structures could have an influence of the appearances of all spinal structures. Apparently, every vertebra shows a different growth property; in general the thoracic and lumbar spine shows an almost exponential growth during childhood and adolescence (Roaf, 1960). Any growth disturbance of the vertebral bodies have the highest impact on the surrounding structures of all major spinal parts (Roaf, 1960). It is not possible to assess the relative impact of intrinsic embryologic and extrinsic mostly mechanical factors on the growth of the human lumbar vertebrae (Larsen, 1985). Its own growth pattern and the one of the surrounding

tissues influence the morphologic appearance of the human spine too. For example, Huizinga *et al.* (1952) linked the narrowing of the lumbar spinal canal to a possible early growth arrest effect.

Other well-known features influencing human skeletal growth are infection and psychogenic factors. Both are difficult to assess in skeletal remains and their magnitude depends on the type and timing of onset. Spinal morphometry and general health status, as expressed by number of specific disease episodes and general practitioner attendances, are known to partially correlate (Porter *et al.*, 1987). People with a narrow sagittal lumbar spinal canal have e.g., more episodes of childhood infections. Furthermore, epigenetic and intrauterine environmental influences seem to have a higher importance than genetic factors in developing the sagittal spinal canal dimensions (Porter *et al.*, 1987). Enzymatic events, acting between the eight to the 16th week *in utero,* the most size-accelerating period, rather than maternal malnutrition, appear to be likely responsible for such spinal morphometric developments (Porter *et al.*, 1987). However, any spinal growth retardation must not necessarily be linked with general growth retardation (Porter *et al.*, 1987). Nevertheless, there seem also to be an association between educational performance and spinal morphometry, as shown by the relationship between schoolchildren test scores and lumbar sagittal spinal canal diameter. Whether this correlation is due to increased sickness-related school absence in the sample with the narrower canal or whether there is a real link between impaired neural canal diameters and early childhood neural development could not be said (Porter *et al.*, 1987).

Based on all these etiological reports on human microevolutionary and secular trends, it is difficult to end up with a convincing hypothesis to explain the found trends of alterations in spinal morphology in the present study. More research would be necessary to focus specifically on selected factors. It is most likely, however, that spinal dimensions are related to body size while reflecting complex demands of biomechanics and protection of nerve pathways. While some of these factors seem to be less likely, such as gene flow, others such as locally different nutrition e.g., in the Medieval Age samples with apparent tall individual stature, could explain at least some of the morphologic alterations.

Importance and functional implications of osteometric spinal data

The important value of spinal morphometric studies for various research fields such as anatomy, orthopaedics e.g., for the precise manufacture of surgical implants or screw insertion depth and direction, biomechanical studies e.g., the use of vertebral body replica in anthropometric-ergonomic studies or comparison with established models of animal spines has already been shown (Saillant, 1976; Kikuchi *et al.*, 1977; Nissan and Gilad, 1984; Nissan and Gilad, 1986; Zindrick *et al.*, 1987; Krag *et al.*, 1988; Marchesi *et al.*, 1988; Banta *et al.*, 1989; Misenhimer *et al.*, 1989; Olsewski *et al.*, 1990; Weinstein *et al.*, 1992; Hou *et al.*, 1993; Vaccaro *et al.*, 1995; Xu *et al.*, 1995; Kothe *et al.*, 1996; Ebraheim *et al.*, 1997; Karaikovic *et al.*, 1997; Kandziora *et al.*, 2001; Mitra *et al.*, 2002). Macerated spines in particular have an enormous potential for the study of their pathologies (Swedborg, 1974) or their normative data and their variability can be used for assessing developmental pathologies of the spine (Piontek and Zaborowski, 1973). Surprisingly, there is still an apparent lack of sufficient

clinically relevant osteometric data of the human spine (Krag *et al.*, 1988). Computer-based simulation in biomechanical studies on the human normal and abnormal spine, as done earlier (Schultz *et al.*, 1972), would benefit from a databank of normal osteometric reference values too. Additionally, osteometric data are useful since they match well with CT scan data (Berry *et al.*, 1987). Furthermore, osteometric reference data of the spine can be used to detect vertebral crush fractures in individuals who do not show established patterns of spinal morphometry (Minne *et al.*, 1988). Finally, osteometric data could also be helpful for studies in forensic anthropology and paleoanthropology (Jankauskas, 1994). One has to be aware that some osseous dimensions exist, which are of even higher clinical value e.g., the effective pedicle diameter (Banta *et al.*, 1989), than the established osteometric measurements. However, this particular measurement could not be assessed in a non-destructive analysis of historic spines. Nevertheless, osteometric data gained from historic non-pathologic spines still have their real value such as e.g., by exploring historic dimensions of spine pathologies.

Spinal morphology has been linked to important clinical pathologies such as lower back pain, in form of e.g., a link between the circular shape of the vertebral endplate and the occurrence of a disc herniation (Harrington *et al.*, 2001), a correlation between the presence of sacralisation of the most lumbar vertebra and sacral pain (Willis, 1924; Willis, 1929; Philipp, 1932; Gill and White, 1955) or the size of the transverse process at L5 and the occurrence of lower lumbar degeneration (MacGibbon and Farfan, 1979). Genetic or mechanical factors influence the spinal morphology and may be responsible for the interaction between stature, general muscular and regional fat build-up and the prevalence of lumbar herniated discs (Heliövaara, 1987). In skeletal

studies, at least the estimated height could give a hint about the individual risk for the occurrence of lower back pain. One has also to be cautious in linking the presence of congenital malformations or anatomical variations of the vertebral column to the occurrence of spinal pathologies (Willis, 1924; Willis, 1929; Giles, 1931; Philipp, 1932; Gill and White, 1955). Nevertheless, by knowing the above mentioned skeletal morphologies, one could assume cautiously, by having similar etiological links in ancient times, the extent and value of degeneration and its subsequent clinical symptomatology in a particular historic individual. In general, humans have large vertebral body surface areas, especially in relation to their body size (Shapiro, 1993). This may be one reason while humans tend to have frequent lower back problems, since the ratio between vertebral body size and its surrounding neural pathways is different from the other most closely related species.

Osteometric dimensions and their possible clinical value: the intervertebral foramen

One example of a possible value of osteometric data not only for anthropological or anatomical purposes but also for clinical issues is the intervertebral foramen size. The osteometric assessment of the intervertebral foramen is just an approximate estimation of its *in vivo* size, which crucially depends on soft tissue and dynamic components (Bailey and Casamajor, 1911; Swanberg, 1915; Larmon, 1944; Magnuson, 1944; Epstein *et al.*, 1962; Jones and Thomson, 1968; Crock, 1981; Panjabi *et al.*, 1983; Vital *et al.*, 1983; Bose and Balasubramaniam, 1984; Vanderlinden, 1984; Lee *et al.*, 1988; Hoyland *et al.*, 1989; Mayoux-Benhamou *et al.*, 1989; Stephens *et al.*, 1991; Yoo *et al.*, 1992; Yoshida *et al.*, 1992; Hasegawa *et al.*, 1995; Inufusa *et al.*, 1996; Nowicki *et al.*,

1996; Schmid *et al.*, 1999; Chung *et al.*, 2000; Lu *et al.*, 2000; Fujiwara *et al.*, 2001; Cinotti *et al.*, 2002). No precise measurements of intervertebral foramina exist that signify the switch from asymptomatic to symptomatic, but it was earlier found that foramina heights and widths are larger in asymptomatic patients than in symptomatic patients (Humphreys *et al.*, 1998). Various critical dimensions of the intervertebral foramen have been proposed so far (Lee *et al.*, 1978; Ciric *et al.*, 1980), despite the fact that even plain radiography seems not to correlate well with the real size of it (Stephens *et al.*, 1991). Furthermore, one has to remember that its size varies depending on axial loading and also during the day (Fujiwara *et al.*, 2001) Additionally, the lateral recess height displays a wide inter-individual variability and shows at least a partial independence of other osseous spinal canal dimensions (Kikuchi *et al.*, 1977). As measured in the present study, the size of the intervertebral foramen would mostly correspond to the size of the mid-zone region of the spinal canal as defined for the lumbar section by Lee *et al.* (1988). Average sizes of adult non-pathologic intervertebral discs are known (Jacobi, 1927; Frobin *et al.*, 1997, Kandizora *et al.*, 2001; Tribus and Belanger, 2001). These data would have to be added to the osseous estimations of the intervertebral foramen size, to compensate for the absence of the disc. However, this still does not represent the real *in vivo* situation, particularly due to *post mortem* alterations of the bony morphometry and other missing soft-tissue components. Nevertheless, the chosen approach in the present study allows reliable comparative temporal studies of the non-pathologic macerated intervertebral foramen size. Earlier reports (Clark *et al.*, 1985) detected no secular trend of the intervertebral foramen size by focusing on influences of prehistoric life-style changes. In contrast, the samples of

industrialized modern societies in the present study demonstrate a mild secular alteration of the intervertebral foramen, even without an apparent major shift in culture. Surprisingly, in the present samples there was also no correlation between osseous intervertebral foramen dimensions and stature or age at death, unlike in previous clinical reports (Humphreys *et al.*, 1998).

Changes in general bony robusticity, as expressed by femoral robusticity, rather than stature, could at least partially explain any secular alterations of the intervertebral foramen size. This is not the case in the modern samples of the present study, which show an insignificant positive increase in robusticity. A positive increase of robusticity would quite likely oppose a secular enlargement of the mostly bony enclosed foramen space.

The stronger expressed secular trends in intervertebral foramen size in females, in the modern samples of the present study, lack an evident interpretation and would need further exploration; especially, since in recent samples intervertebral foramen and spinal canal size show mostly no significant sexual dimorphism (Lee *et al.*, 1995; Ebraheim *et al.*, 1996).

The results from the present study proclaim a secular narrowing of the intervertebral foramen diameters, as a possible microevolutionary pre-condition of radiculopathy or general spinal stenosis, to be unlikely. The mild secular trend of the intervertebral foramen diameters may not correlate with alterations in clinical presentation, since earlier studies focusing on possible links between altered spinal neural pathways and clinical symptoms showed inconsistent results (Boden *et al.*, 1990; Hasegawa *et al.*, 1995; Humphreys *et al.*, 1998). For example, an astonishingly high

number of approximately 30% abnormal lumbar spinal MRI scans, such as spinal stenosis, has been reported in a series of asymptomatic individuals (Boden *et al.*, 1990). Similar results have also been mentioned for CT scans (Wiesel *et al.*, 1984). Therefore, a link between pathologic appearances in the spine, at least in imaging situations but most likely also in skeletal remains, and clinical symptoms must not be regarded as being absolute.

Conclusions

In the present study, it has been shown that the normal human vertebral column displays a certain degree of plasticity. For example, with individual age not only the vertebrae themselves become bigger, as seen statistically significant for males, but also pedicle height increases. Since no such clear trend is visible for the neural pathways, which represent some sort of negative of the bony outline or an empty space, respectively, this may be explained by a general increase in the bony framework. Apparently, despite the well-known loss of bony strength with age, the aging vertebral column shows bone remodelling, increased robusticity and degenerative bone apposition, with the latter one not relevant for the present study due to the exclusion of any pathologic skeletons. Since some altered osseous dimensions are linked with clinical symptoms (Porter *et al.*, 1978a; Porter *et al.*, 1980; Macdonald *et al.*, 1984) the knowledge of osteometric data, even from historic populations, allows to speculate about its possible clinical implications. However, the question remains still unsolved whether the high prevalence of lower back disorders in modern humans is a result of inadequate spinal or body morphology (Heliövaara, 1987; Harrington *et al.*, 2001) or rather caused by our inappropriate life-style (Boszczyk *et al.*, 2001).

Any microevolutionary or secular spinal trend may represent so called "relaxed natural selection", which is particularly visible in developed countries and may decrease the ability of humans to survive and reproduce without medico-technological help (Stephan and Henneberg, 2001). The selection forces acting particularly on the human spinal column are still mostly unknown. For example, humans, despite having a much larger relative brain weight, do not have a bigger spinal cord weight in comparison with other primate and mammal species (MacLarnon, 1996b). Therefore, one can assume that the selective powers influencing the spinal morphology must be different from the ones interfering with the other central nerve system part, the human brain. Possible etiologies of the findings in the present study may be, as pointed out in earlier microevolutionary studies (Wiercinski, 1979; Wurm, 1982; Henneberg and George, 1995; Rothschild and Rothschild, 1996; Henneberg and Henneberg, 1999; Hukuda *et al.*, 2000), based on genetic e.g., changing allele frequencies, or environmental influences e.g., nutrition. In general, the microevolutionary and secular trends in the present sample show that there is ongoing influence, mostly balanced between environmental and genetic factors, which acts on the human spinal column.

The challenging results, as presented above, will hopefully stimulate the debate, which assesses spinal morphology changes by using a historic perspective (Clark *et al.*, 1985; Porter and Pavitt, 1987; Jankauskas, 1992; 1994; Henneberg and Henneberg, 1999; Hukuda *et al.*, 2000; Boszczyk *et al.*, 2001; Tatarek, 2001; Rühli *et al.*, 2002). It builds a bridge between anthropological approaches and clinical research, and it should help to improve our still limited knowledge on the ongoing evolution and the osteometric variation of the human vertebral column.

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Appendix

1. List of abbreviations for measurements used

Abbreviation	Variable
BP	year of birth before 2000 A.D.
Agegroup	Adult (Agegroup1); Matur (2), Senil (3)
C3M2	C3 dorsal vertebral body height
C3M1	C3 ventral vertebral body height
C3M6	C3 sagittal diameter vertebral body
C3M9	C3 transverse diameter vertebral body
C3PHl	C3 left pedicle height
C3PHr	C3 right pedicle height
C3M10	C3 sagittal diameter spinal canal
C3M11	C3 transverse diameter spinal canal
C3SPL	C3 spinous process length
C3TPW	C3 transverse process width
C3IFlcr	C3 left cranial intervertebral foramen width
C3IFlca	C3 left caudal intervertebral foramen width
C3IFrcr	C3 right cranial intervertebral foramen width
C3IFrca	C3 right caudal intervertebral foramen width
C7M2	C7 dorsal vertebral body height
C7M1	C7 ventral vertebral body height
C7M6	C7 sagittal diameter vertebral body
C7M9	C7 transverse diameter vertebral body
C7PHl	C7 left pedicle height
C7PHr	C7 right pedicle height
C7M10	C7 sagittal diameter spinal canal
C7M11	C7 transverse diameter spinal canal
C7SPL	C7 spinous process length
C7TPW	C7 transverse process width
C7IFlcr	C7 left cranial intervertebral foramen width
C7IFlca	C7 left caudal intervertebral foramen width
C7IFrcr	C7 right cranial intervertebral foramen width
C7IFrca	C7 right caudal intervertebral foramen width
T1M2	Th1 dorsal vertebral body height
T1M1	Th1 ventral vertebral body height
T1M6	Th1 sagittal diameter vertebral body
T1M9	Th1 transverse diameter vertebral body
T1PHl	Th1 left pedicle height
T1TPHr	Th1 righ pedicle height
T1M10	Th1 sagittal diameter spinal canal
T1M11	Th1 transverse diameter spinal canal
T1SPL	Th1 spinous process length
T1TPW	Th1 transverse process width
T1IFlcr	Th1 left cranial intervertebral foramen width
T1IFlca	Th1 left caudal intervertebral foramen width
T1IFrcr	Th1 right cranial intervertebral foramen width
T1IFrca	Th1 right caudal intervertebral foramen width
T6M2	Th6 dorsal vertebral body height
T6M1	Th6 ventral vertebral body height
T6M6	Th6 sagittal diameter vertebral body
T6M9	Th6 transverse diameter vertebral body
T6PHl	Th6 left pedicle height
T6PHr	Th6 right pedicle height
T6M10	Th6 sagittal diameter spinal canal
T6M11	Th6 transverse diameter spinal canal

T6SPL	Th6 spinous process length
T6TPW	Th6 transverse process width
T6IFlca	Th6 left caudal intervertebral foramen width
T6IFrca	Th6 right caudal intervertebral foramen width
T10M2	Th10 dorsal vertebral body height
T10M1	Th10 ventral vertebral body height
T10M6	Th10 sagittal diameter vertebral body
T10M9	Th10 transverse diameter vertebral body
T10PHl	Th10 left pedicle height
T10PHr	Th10 right pedicle height
T10M10	Th10 sagittal diameter spinal canal
T10M11	Th10 transverse diameter spinal canal
T10SPL	Th10 spinous process length
T10TPW	Th10 transverse process width
T10IFlca	Th10 left caudal intervertebral foramen width
T10IFrca	Th10 right caudal intervertebral foramen width
L1M2	L1 dorsal vertebral body height
L1M1	L1 ventral vertebral body height
L1M6	L1 sagittal diameter vertebral body
L1M9	L1 transverse diameter vertebral body
L1PHl	L1 left pedicle height
L1PHr	L1 right pedicle height
L1M10	L1 sagittal diameter spinal canal
L1M11	L1 transverse diameter spinal canal
L1SPL	L1 spinous process length
L1TPW	L1 transverse process width
L1IFlcr	L1 left cranial intervertebral foramen width
L1IFlca	L1 left caudal intervertebral foramen width
L1IFrcr	L1 right cranial intervertebral foramen width
L1IFrca	L1 right caudal intervertebral foramen width
L5M2	L5 dorsal vertebral body height
L5M1	L5 ventral vertebral body height
L5M6	L5 sagittal diameter vertebral body
L5M9	L5 transverse diameter vertebral body
L5PHl	L5 left pedicle height
L5PHr	L5 right pedicle height
L5M10	L5 sagittal diameter spinal canal
L5M11	L5 transverse diameter spinal canal
L5SPL	L5 spinous processus length
L5TPW	L5 transverse process width
L5IFlcr	L5 left cranial intervertebral foramen width
L5IFlca	L5 left caudal intervertebral foramen width
L5IFrcr	L5 right cranial intervertebral foramen width
L5IFrca	L5 right caudal intervertebral foramen width
FMM16	sagittal diameter foramen magnum
FMM7	transverse diameter foramen magnum
HLM1	maximum humerus length
HCM7	humerus minimal circumference
FHM18	femoral head width
FLM1	maximum femur length
FCM8	mid-femur circumference
BIWM2	bi-iliac width

Males

Individual / Sample	Specimen number	BP	agegroup	C2M2	C2M1	C2M5	C2M9	C2PHI	C2PHV	C2M10	C2M11	C2SPL	C2TPW	C2cFlor	C2cFlos	C2cFlor	C2cFlos	C7M2	C7M1	C7M4	C7M3	C7PHI	C7PHV	C7M10	C7M11	C7SPL	C7TPW	C7cFlor	C7cFlos	C7cFlor	C7cFlos	T1M2	T1M1	T1M5	T1M9	T1PHI	T1TPW
LaFerrassie	1	30000	2	12.8	12.1	18.5	19.8		6.2	15.2	28.1	15.8		9.3	10.4	5	10.8							14.2	25.1	41.3						15.2		32.4	10.8	11.1
LaChappelleauxSaints	1	30000	2															12.3	11.6	17.9	29.1	6	5.8	14.1	28	33.5		4.7	7.8	5.6	11.2	14.2	13.3	16.6		7.6	7.1
CroMagnon	1	25000	2															14.7	11.5	16.8	25.7	6.3	6.5	14	23.1			3.5	9.1	5.6	8						
AbriPataud	6	18250	1	12.9	12.8	14.3	20.3	7.2	6.5	12.8	22			6.3	7.8	5.3	7.9					6.4	6.1		23.6	30.4	68.4	5.7		6.1							
Neuessing	2	15200	1	12.1	12	14.4	22	6.6	5.4		22.8		50.5	6.3	7.8		7.9	13.6	12.2	15.4	28.6	6.1	5.2	15.2	25			5.2	10.8	6.2	10.4						
Veyrier	1	12000	1																																		
LaBichon	1	11700	1																													14.5	14.2	16.9	21.2	6.8	6.5
Teviec	16	8000	1	13.5	13.4	17.1	23	8.5	7.9	14.2	22.2	15.1	55.9	4.3	6.9	5.4	7	13.6	14	17.7	26	6	6	13.2	23.2	30.5	68.4	7.4	9.3	6.8	9.7	16.3	15.6	17.3	25.1	9.6	9.5
Gramet	1	8000	1	14.1	13.2	17	21.8	6.2	7.4	14.6	23.3		58	6.1	7.3	6	6.8	14.5	14	17.7	26.9	5.6	6.2	14.2	23.5	28.8		6.3	8.4	6.9	9.6	17.5	16.8	17.6	26.4	8.9	7.6
Vaihingen	8	7200	2	14	12.1	15.6		7.5								5.6	7.7																				
Vaihingen	19	7200	1																																		
Vaihingen	90	7200	2																																		
Vaihingen	7	7200	2	14.1	14.2	15.7	18.1											13.7	14.7	16	24.2																
Wanderslaeben	2172	7000	2																																		
Wanderslaeben	2235	7000	3																																		
Wanderslaeben	2221	7000	1																													17.6	16.1	17.3	26.3	10.6	8.4
Wanderslaeben	2220	7000	3	14.1	12.9	17.2	17.6	8.2	7.8	14.2	21.1	12.6	45.4	3.6		4.8	5.5																				
Wanderslaeben	2235	7000	3	12.9	15.7	14.9	19.2	6.6	5.8	18.6		14.1	49.8	6.4	6.9	5.1	6.6	13.5	13.3	17.2	30.9	6.9	6.1	15.3	26.3	31.5		6.2	8.7	7.4	8.5						
Wanderslaeben	2165	7000	1	12.1	13.2	15.4	21.5	6.1	5.4	14	22.8		49	5.1	4.8	6.9	7.1	12.6	12.9	15.4	23	5.9	5.7	13.4	25.1	28.2	47	5.5	8.7	6.5	8.4	15.8	15.2	15.8	26.9	8	7.3
Wanderslaeben	2126	7000	2															14.6		19.2	29.6	9.3	8.5	13.8	24.4			5	7	5.2	7	17.3	19.1	26.8	10.1	9.5	
Wanderslaeben	2219	7000	3	14.6	11.8	13.6	17.8	7.4	7.4	13.8	23.7		53.5	4.7	8.3	5.4	6.4	15.8	14.8	16.2	25.3	5.5	6.2	13.2	19.8			4.1	6.6	5.8	6.4	17.1	15.8	15.5	27	11.6	10.2
Wanderslaeben	2141	7000	2	14.7	14.4	18.6	19.7	8.5	7.5	13.8	21.9	13.5	50.1	4.9	5.3	5.6	6.6	15.2	14.8	17.5	26.9	6.3	7.2	13.9	23.5	35.4	49.8	5.1	8.1	6.4	7.3						
Wanderslaeben	2257	7000	2	13.5	12.5	17.3	22.6	8.9	8.8	15	20.5		52.3		5.8	5.4	5.8	14.3	13.3	15.8	29.6		6							6.8	8.3	16	15.3	17.5	30.8	9.9	10.4
Wanderslaeben	2145	7000	1																																		
Wanderslaeben	2163	7000	1	13.6	13.5	14.8	22.5	7.5	7.2		25		52.2	6.5	6.9	5.4	6.2															17.9	16				9.6
Wanderslaeben	2284	7000	1	14.6	13.2	18.7	24	8.6	8.6	12.8	24.7			3.5	4.5	3.8	5.2															19.5	17	17.8	26.6	10.1	9.2
Wanderslaeben	2211	7000	3	13.5	14.1	18.6	20.9	7.9	7.8	11.5	22.8		53.7	4.2	5.5	5.6	3.9	15.1	14.8	17.3	27.4	6.2	6	12.6	23.3	30.7	49	4.4	8.5	4.1	7.8	19.5	17	17.8	26.6	10.1	9.2
Wanderslaeben	2115	7000	1	14.2	13.9	16	21.4	8.6	8.1	15.5	22.5		49.5	4.3	6.3	5.7	6.3	15.2	15.1	16.5	27.2	7.9	8	15	23.4	30.5		5.7	9.8	5.7	9.3	17.9	16.6	16.5	27.7	11.5	11.9
Hoelzlc	9	6400	1																																		
Hainburg	21125	3800	1	13	13.2	13.9	17.1	7.2	6.9	14.8	21.7			5.9	7	5	5.4	14.4	14.4	14.6	24.5	8	8.8	13.7	21.3	34.2	68.1	5.9	8.8	5.6	9.6	15.9	15.8	15.6	25.1	9	9.8
Hainburg	21055	3800	1																13.3	14.8	28.5	6.4	5.9	14.6	25.3	29.8		5.3	9.1	6.4	8.8	15.6	15.3	15.9	31.4	9.2	8.3
Hainburg	12145	3800	2	14.6	12.8	17.3	20.2	6.9	5.8	14.1	23.5			5	6.5	5.8	6.2		13.1	15.6	30.2	6.5		15.7	22.1			5.6	9.3		8.5	16.6	15.1	17	30	9.8	11.1
Hainburg	13030	3800	1	11.4	12.3	13	18.8	5.4	5.5	15.8	24		50	7	8.2	5.8	6.8	12.8	12	15.7	26.8	6.4	5.8	13.8	24.5	19.3		6.9	10.4	7.1	9.5	15	14	14.8	26.5	8.1	7.8
Hainburg	12144	3800	2	14.5	13	18.7	23	8.2	8.3	12.8	21.8			6.1	6.2	6.2	6.9	15.1	13.4	16.7	29.2	7.2	7.2	14	25			5.3	7.8	5.9	9.8	16.8	16.4	20	35.4	12.4	
Hainburg	9708	3800	1	13.6	12.9	15.6	21	6.6	6.3	14.8	22.8			5.4	6.8	6	7.5	14.3	12.9	16.8	25.6	7.3	5.7	14.5	24.7	30.2		5.3	8.8	4.8	8.8	16.8	14.8	15.8	31.1	10.5	9.5
Hainburg	21027	3800	1	14	14	14.2	18.4	8.4	8.1	16.8	25.3	21.6	60.2	8.5	9.6	8.3	8.4	14.9	14.4	15.6	21.8	7.6	8.2	17.4	24.8	30.1		6.5	10	7.2	10.7	17.5	15.9		29.5	10.9	10.2
Hainburg	9687	3800	2	14.1	13.6	15	23.2	7.5	5.7	14	22.7		57.6	7.5	6.2	7.3	8.3	15.5	14.6	15.8	27.2	8	7.5	15.2	22.6	31.5		5.4	8.5	5.4		18	16.5	16.1	28.5	10.5	9.8
Hainburg	12134	3800	1	15.2	14.5	14.6	21.1			14	24.8	20.9	56.9	7.8	8.2	6.4	8.5	14	13.8	16.2	27.9		7.1	12.4	28.6	33.2		5.2	8.8	5.5	6.6	15.8	15	15.6	31.4		8.3
Hainburg	13053	3800	1	12.5	11.2	16.2	22.1	5.2	6.5	15.3	23.8		59	9.1	10.3	7.5	8.9	14.8	13.8	16.1	23.9	5.8	7.3	17.9	23.3	27.8		6	10.6	6.2	12	16.8	15.2	16.6	30.2	9.3	8.4
Hainburg	12200	3800	1																													19.6	18.4	17.8	30.1	10.9	10.4
Hainburg	21115	3800	1															15.4	15.2	14	23	7.5	7.4	16.3	26	24.7		6.7	9.8	7.8	9.6	19.8	18.7	14.5	26.2	9.1	
Hainburg	13033	3800	1	13.4	13.5	12.3	19.8	7			22.5			5.8	7.2			14.7	14.8	14.3	26.2	6.2	6.8	15.4	22.9			7.9	11.2	6.8	11.3	17.6	16.4	15.9	29.5	9.9	9.3
Hainburg	12143	3800	1																													16	14.9	16.5	28.6	8.1	8.3
Hainburg	13066	3800	1	13.4	13.7	13.4	19.3	6.9	6.8	15.5	22	13.5	50.9	6	6.8	6.4	7.3	15	13.2	15.8	23.6	6.9	7.4	13.1	22.9			6.5	8.7	6	8.3						
Hainburg	8723	3800	1	13	13.8	14.9	20.4	5.3	5.8	16.1	24.3			7.2	9.3	7.7	8.9	14.3	13.6	17.2	25.7	6.3	6.2	15.8	26.9			7.6	10.5	8.1	10.3	16.8	18	18.5	27.4	8.1	7.4
Hainburg	21081	3800	1															15.3	14.2	15.8	21.1	6.3	6	13.5	23	28.9		5.6	11.1	5.7	10.2	15.8	14.8	16.9	25.8	8.5	8.4
Straubing	683	1400	2	14.6	14.1	15.6	18.4	7.2	6.7	15.6	24.5		57.2	7.1	7.6	6.9	8.1	15.2	14.2	16.8	26.5	6.7	6.9	16	25	32.5	73.2	6.6	9.3	6.9	9.8	17.6	15.9	16.8	31.6	8.4	9
Straubing	605	1400	2															15.9	15.3	17.3	28.2	6	7.4		27	25.5		7.6		7.7	12.4	17.6	17.5	18.6	30.1		12
Straubing	308	1400	2															14.9	14.3	16.6	22.2	7.3	6.1	17.5	27.5			6.5	11.9	7.2	11.5	15.9	15.9	17.7	25.6	7.4	7
Straubing	766	1400	1	13.6	14	13.7	18.7	6.7	5.6	15.9	23.1			6.3	6.3	5.1	8.4	15.4	15.2	14.7	21.2	6.6	7.3	15.9	23.6			7.2	9.3	6.8	9.9	17.6	17	15.1	24.3	10	10.7
Straubing	639	1400	2	10.8	12.9	17.8	20.3	7.4	7.8	14.3	23			6.2	7.6	5.3	8.9															17.1			30.2	10.7	10.6
Straubing	491	1400	1	13.8	13.6	15.4	20.6	7.1	7.1	14.5	23.5			5.6	5.6	5.8	7.1	15.2	15.1	17.5	26.4	7.8	7.2	14.9	25.2			5.1	11.2	5.4	10	16.6	16	18.2	27.2	10.8	9.9
Straubing	373	1400	2	14.8	14.8	17.4	20.7	7.5	7.5	13.4	23.8	19.6	50.6	6.1	6.6	5.3	7.6	15	13.8	16.9	31.1	9.2	8.4	14.2	26.1	27.2		5.7	9.5	5.9	10.3	19	15.4	15.8	28.8	11.5	11.2
Straubing	368	1400	2	15.8	15.5	16	17.2	7.1	6.3	14.3	26.5			8.1	9.4	8.1	9.2	15.1	15.6	17	27.2	8.6	8	14.2	26.9	26		7.4	11.2	6.2	11.3	18.9	18.1	15.9	29.2	9.8	11
Straubing	275	1400	2	11.1	11.5	16.2	17.8	5.6	5.9		22.9		52.6	6.5	6.7	5.3	6.8	13.5	10.2	18.5	25.8	7	7	14.6	25.5			5.8	8.8	4.9	9.8	15.4	15	17.8	24.3	7.8	9
Straubing	626	1400	2	14.3	15.1	18.1	18.5	8.2	7.6	13.2	24.2		62.2	6.9	7.5	7.3	7.8	15.2	14.2	17.8	28.3	7.6	7.8	13.5	23.7		76	6.1	9	5.9	9.6	15.2	15.7	17.6	31	9.8	10.5
Straubing	433	1400	1	14	13.2	15.8	18.2	7.2	7		24.2		52.8	6.4	7.1	6.5	5.8	13.5	13.8	17.4	25	7.7	8	15.5	24.4	25.2		6.5	10	5.9	10.4	16.9	15.8	17.3	23.9	9.2	9.9
Straubing	745	1400	2	14.8	13.9	18.6	19.1	6.7	6.3	13.8	25.6			6.8	9.6	5.1	8.5	15.8	14.8	16.8	29.2	6.8	7.5	15	24.8	31.2		4.4	10.1	5.3	10.4	19.2	16.8	18.6	31.1	9.6	9.4
Straubing	363	1400	2					4.2		16.8	24.5							15.8	15.1	18.1	25.8	6.9	6.5	17.5	27			6.3	11	6.8	11.1		13.7				
Straubing	501	1400	2	13.9	13.2	14.2	14.6	7.5	7.1	16	25.9	18.6	59.6	6.4	8.4	7.3	7.5	14.8	14.8	14.6	26	6.5	6.3		26.8							19.2	17.5	15.8	27.7	9	8.8
Straubing	272	1400	2	14.5	14.6	15.7	22	7.8	6.4	17.7	24.1	17.8	57.2	5.8	7.3	6.9	9.6															15.5	16.2	17.7	26	9.5	9.1
Straubing	636	1400	1	13.7	13.3	14.7	19.2	5.7	5.8	17.3	25.8	13	51.7	9	7.8	8.2	8.7	15.8	15.2	15.2	25.1	6.2	6.3	17.5	26	26.8		6.2	9	7.2	9.2	19.2	16.9	16.5	30.1	8.5	8.7
Straubing	412	1400	2	12.2	13	15.1	14	5.2	6	14.3	24.4		48.4	6.7	8.6	6.4	7.4	12.6	12.2	17.8	21.8	6.1	6.3	14.2	25.4	17.8		6.3	8.4	6.8	8.5	14.2	14	16.7	26.8	6.8	7.9
Straubing	605	1400	2															15.9	15.4	17.9	27.7	8	7.9		26.7	26.5	72.4	7.8	12.7	7.8	12.8						
Straubing	260	1400	1	12.6	14.8	14.7			6.2							5.8	8.9	16.1	14.3	14.7												19	15	16.5	32	10	10.9
Straubing	463	1400	2	14.9	14	17.7	21.1	8.5	8.3	13.2	25.8		58.8	6.5	7.3	5.8	7.4	14.6	14.2	17.9	25.3	7.8	7.8	17.7	26.1			6	9.8	6.8	10.8						
Straubing	500	1400	1	12.8	12.7	14.6	17.9	8.3	5.8	14.3	23			6.3	6.2	6.6	6.5	13.2	13	15.8	22.8	6.7	6.1	13.5	23			6.3	9.8	6	9.6	15.1	13.2	15.8	24.5	8	8.2
Straubing	640	1400	3																																		
Straubing	418	1400	1	11.9	11.1	12.4	18.1	5.4	5.8	18.1	24.2	22.7	51.9	9.2	8.2	6.8	9	14.6	14.3	13.9	21.3	7.6	6.2	17.8	25.1	28.5		6.8	11.4	7.2	12.1	16.8	14.4	14.6	27.9	9.3	8.9
Straubing	370	1400	1	13.8	14.2	15.8	18.1	8.7	6.8	15	23.6		58.2	6.6	7.9	7	8.4	16.1	14.6	15.4	25.6	8.5	8.1	14.6	26.2			6.2	9.8	6.6	10.8	17.1	16.1	17	33	9.4	10.3
Straubing	731	1400	2	12.9	13	16.6	22.5	7.2	7.6	16	22.5	19.8		5.9	8.6	7.1	9.1	13.2	12.9	18.8	25.6	7.1	7.2	14.5	23.2	24.8		7.4	10.8	6.8	10.4	16.1	14.6	16.2	29.3	8.6	10.8
Straubing	763	1400	1	14.1	13.8	14.6	19.1	6.1	6.5		26			7.1	10.5	8.3	8.5	15.8	14.1	14.8	25.8	6	6.5	14.3	24.4			6.6	11.6	7.1	11.7						
Straubing	806	1400	2	13.8	13.1	16	18	7.3	6.2	14.4	25.5		54.4	5.1	8.1	6	8.3	14.8	13.9	17.7	26.9	7.2	6.4	15	26.2	32.7	53.9	7.8	10.4	7	9.4	17.3	15.1	17.3	30.1		
Straubing	765	1400	2																																		
Straubing	493	1400	2	14	14	15.5	17.6	7.4	8.1		24.2		53	7.6	7.7	6.6	7.8																				
Straubing	438	1400	2															14.5	14.2	15.7	25.2	7.7	7.8	13.9	24.1	24.5	69.8	5	9.7	5.3	8.8	16.8	16.1	16.5	26.5	9.3	11.4
Straubing	655	1400	2	13.4	13	15.9	17.6	6.8	5.8	14.3	25.8	17.5	53.5	5.5	8.8	7.2	9.3	14.8	13.6	16.8	26.7	6.6	5.7	15	23.8	32.2		7.6	10.3	7.1	9.8	17.2	15	16.6	30.5		
Straubing	301	1400	2	13.2	12.2	14.9	18.3	6.1	8.2	15.6	22.8			6.5	7.8	5.9	9.4	14.8	13.6	15.1	25.2	7.2	5.7	13.9	24.1			6.2	10.4	7	9.4	17.5	14.8	12.9	31.6	8.7	8.2
Straubing	675	1400	2																													17.2	17	17.4	23	9	8.2
Straubing	356	1400	1					8.6	16.2			14.1				6	7.8							16.7	25.9	27		6.8	10.6	6.7	10.4	18.6			26.8	11.2	9.8
Straubing	378	1400	2												9.3	6.3	10.2	13.6	12.2	17.8	27.1	6.8	7.6	15.5	24.2			6.5	10.4	7.1	10.1	16.8	14.1	16.5	32.5	9.9	8.8
Straubing	296	1400	2															16.4	16.2	17.1	25	8.7	8.9	15.7	24.6	31.2		5.7	11	6.7	11	17	19.2	16.5	26.9	10.8	9.8
Straubing	791	1400	2	12.5	12.5	15.9	18.7	5.8	6.3	15.6	24			7.1	7.9	5.8	8.8	13.2	12.6	18.8	25.9	6	6.2	14.6	26.4			5.8	9.6	6.6	10.1	15.2	14.5	16.8	25.6		8.3
Aasch	23	1335	2	13.2	13.9	16.5	16.8	6	5.4	17.6	23.7			4.4	7	6.2	7.6	13.6	12.4	17.1	28.8	5.8	5.2	16.7	27.6			5.5	8.9	6.7	8.9	16	14.5	17.9	27.3	7.8	7.6
Aasch	4	1335	2	13.2	11.4	17.4	18.1	7.5	6.9	13.8	23.8			5.4	9.5	5.3	7.5	14.9	14	17.8	27	7.5	6.6	14.8	24.3	35.9		5.8	8.8	6	10.6	17.2	15.2	17	23.5	8.5	9.8
Aasch	35	1335	2	13.3	12.5	15.7	18.8	5.6	5.9	15.3	24		55.2	4.4	7.2	4.6	5.1	15.2	15.5	16.9	27.9	6.9	6.8	16.1	23.6			5.1	10.5	4.9	10.4	17.3	14.4	17.5	28.4	10.3	10.8
Aasch	12	1335	2	15.7	15.2	14.2	20	9	7.4		27			6.8	8.3	6.4	8.1	15.8	14	17.1	29	8.4	7.2		26.9			6.1				17.8	17.9			8.6	
Aasch	29	1335	1																																		
Aasch	36	1335	3	15	15.9	17.6	21.6	7.4	6.8	16.9	26.5		62.8	6.3	6.9	6.3	6.3	16.3	13.5	19.6	28.1	6	7.3	16.5	30.6			7.1	9	6	10.2	17.3	15.4	18.5	30.4	7.8	9.3
Aasch	19	1335	1	14.5	13.7	15.4			6.7							6.6	7.7	14.6	15.1	16.2	25.9	6	6.7		25.3			5.8		6.1	8.1	17	15.8	17.6	24	8.6	8.5

Individual / Sample	Specimen number	BP	age group	C3M2	C3M1	C3ME	C3Mb	C3PH	C3PHr	C3M10	C3M11	C3SPL	C3TPW	C3IFcr	C3IFca	C3IFcr	C3IFca	C7M2	C7M1	C7ME	C7Mb	C7PH	C7PHr	C7M10	C7M11	C7SPL	C7TPW	C7IFcr	C7IFca	C7IFcr	C7IFca	T1M2	T1M1	T1ME	T1Mb	T1PH	T1TPHr
Aesch	48	1335	1	14.9	15	16.4	20.8	7	7.9	13.9	26.4		54.4	6.2	7.4	6.1	4.2															17.9	17	16	26.2	9.3	9.3
Aesch	10	1335	1																																		
Barbing	1355	1300	2	14.2	14.8			6.6	5.9		24.8			6.2		4.9		14.2	13.9	19.5	32	6.5	6.8	13.6	26.1			7	8.6	6.2	8.4	17.4	17.4	19.5	31.4	10.4	10.2
Barbing	1355	1300	3	15	15.8	17.6	18.3	7.8	8	16	24.5		55.8	5.4	8.3	5.3	6.8	15.2	15	18.5	27		7.6	15.7	25	29.8	31.2	5.5	9	5.4	9.6	18.5	17.4	19.5	29	11	10.3
Barbing	1260	1300	2	15.1	16.3	16	19.1	7.8	8.9	11.8	22.9		53.1	6	7.3	6.6	7.7	17	17.2	16.1	22.4	6.2	8.5	12.8	22			5.3	8.3	6.2	6.4	19.8				12.1	10.4
Barbing	1340	1300	2	13.7				6.5	7.4	14.3	24.1	16.6	49.6	5.6	6.5	5.2	6.1	15.5	14.9	16.6		5.9										16.5	16.5	17.9	27.1	9.4	9.1
Barbing	1373	1300	3	14.7	14.8	16.1	14.6	8	8.2	14.4	23	22	52.6	5.9	7.5	6.2	8.4	16	15.5	16.4	27.1	7.7	7.9	14.1	23.2	37.9		6.5	10.5	5.8	10.5	19.2	17.9	17.1	32.5	11	10.3
Barbing	1330	1300	2															15.3	15	17	27.8	5.7	6.6	15.1	24.8			5.2	8.8	5.8	6.7	18	16.1	17.7	31.3	10	8.9
Barbing	1326	1300	1	12.2	12.3	14.5	16.6	6.4	5.7					6.8	8			13.8	11.8	14.5	23.5	6.9	6.7	15.2	24.1			6.7	9.5	6.7	9	16	14.2	14.3	24.4	7.6	7.4
Barbing	1379	1300	2															15.7	15.3	19.5	28	6.8	7		27.4					6.5	9.3	18.5	18	18.5	31.9	8.9	9
Barbing	1294	1300	2	15	15.5	14.8	18																														
Barbing	1371	1300	2															15.1	13.8	18.6	25.8	8.6	8.5	14	22.3	33.9	84.6	6	9.2	6.2	8.8	17.9	18.1	19.8	31.2	10.3	9.8
Barbing	1266	1300	3	14.5	15	17.3		7.8	7.3	15.2	24.4		56.5	5.8	5.7	5.1	6.3	14.6	12.8	19.8	21.5	5.3	6.2	15.1	26.7	26.4	81.4	5.1	8	5.3	8.5	16.5	15.9	19.4	32.4	8	8.7
Barbing	1395	1300	2	15.1	14.8	16.8	19.3	6.5	7.3	14.2	24.5		52.2	5.8	7.4	4.9	7.1	14.7	13.7	18.2	24.1	7.5	6.7	13.7	24.5		51.8	5.1	8.5	5.3	8	17.5	16.1	18.4	34.7	9	9.6
Barbing	1288	1300	2	12.5	13.2	17.6	15.1	6.5	6.5	13.6	20.1		47.3	5.3	5.8	5.8	6.2	13.4	10.2	17.3	23.5	8.4	7.5	14	25		52.4	5.2	7.8		7.7	13.6	13.5	17.5	24.8	8.4	9.2
Barbing	1277	1300	1	15	11.5	15.9	18.8	6.4	6.6		25.5		51.8	6.7	7.6	6.5	7.9	15.4	14	16.8	24.1	7.5	7.5		25.6			5.6		6.2		17.7	16.9	16.4	30.6	9.1	8.6
Barbing	1299	1300	3	14.7	12.9	15.7	20.5	7.8	6.9	15.3	24.2			6.5	7.6	7.1	8.1	14.3	14.4	17.7	29.3	6.4		15.1	24.8			6.1		6.8		19.5	18.4	18.6	29.8	12.3	11.9
Winterthur	6	950	1	13.8	14.1	15.7	18.6	6.3	5.8	17.5	23.7	11.4		7.4	8.7	6.4	8.4	15.9	14.4	15.5	26.5	6.9	7.2	14.6	25.9			6.5	11.7	6.4	11.6	17.7	15.5	16.1	28.3	9.4	10.5
Winterthur	141	800	2																																		
Chur	66	650	2															16.5	14.8	17.5	26.6	7.8	8	15.5	26.9	27.6	77	6.5	11.4	6.5	10.3	19.7	16.5	18.4	30.9	9.1	9.2
Chur	46	650	1	13.7	14.5	16.6	17.9	6.8	7.2	15.4	25.1	11.1	54.8	5.4	6.8	5.8	7.2	14.5	14.1	15.8	25.8	6.6	6.5	13.7	26.5	26.5	70.1	5.6	8.5	6	7.2	16.4	15.5	16.4	25.9	9.6	8.8
Chur	69	650	2			14.2	15.5	20.4			15.3	23.8		6.6	6.8	7.1	7.7	14.6	13.1	20.1	30.7	6.9	6.6	12.3	27.3	31.3	40.1	5.2	9.6	5.1	8.2	15.8	15.3	19	29.8	9.2	8.8
Chur	40	650	2	11.5	12.1	16.3	16.4	6	6.3			23.5	59.6	6.5	9.4	6.2	7.8	13	11.6	19.6	26.5	6.5	6.5	12.6	25.4	24.1	74.1	6	10.1	6.5	10	14.1	12.5	19.5	22.8	8.2	8.5
Chur	533	650	2																																		
Chur	30	650	1	12.6				6.1	6.4	15.3	23.2			5.1	7.2	6.1	7	14				7.3	6.7	13.8	23.2			6	9.5	6.2	10.7	15			23.5	8.6	7.5
Chur	408	650	2																														18.1	19.8	28		
Chur	31	650	2																																		
Winterthur	84	600	1	15.2	15.3	15.5	20.2	6.5	6.2	15.8	26.6	20.1		5.5	9.6	6.5	8.3	17.8		18.1	30			15.8	19.1	32.5	76.2	7.5	12.3	7.3	11.9	19	19.4	19.5	28.8		
Winterthur	24	600	2																													16.9	15.6	18.8	26.4	6.9	8.2
Winterthur	80	600	1	14.2	14	14.9	19.5	7	6.7	15.7	26.9	21.7	54.8	7.8	9.6	6.9	9.6			17.3	28.6			16.7	18.9		69.1		11.8	6.9	11.3	15.9	15.2	16.7	27.1	7	7.1
Winterthur	51	600	2	13.2	12.6	17.3	20.5	7	8.1	14.4	23.8		57.2	4.9	7.7	5.6	9.5	14.1	15.8	16.9	26.7			14.5	20.7	32.8	77.3		10.2	5.6	9.4	17.3	15.8	16.9	26.7		10.8
Winterthur	79	600	2	13.3	14.4	15.3	17.8	6.6	5.8	16.2	22.9	17.8	53.2	6.6	6.5	6.8	6.3	14.2	12.4	19.2	25.6	8.5	7.9	14.1	26.4	26.3	78	5.4	9.4	6.8	9	17.8	16.3	17.4	24.2	9.1	9.8
Winterthur	90	600	1	12.5	13.4	14.8	17.6	6.5	6.3	15.2	23.5	14.1	53.2	5.8	8.8	5.9	7.5	15.1	13.6	15.6	25.5	7.6	7	13.5	24.9			6.3	8.4	6	9.3	16.8	14.7	15.8	26.6	10	9.8
Winterthur	72	600	1	13.8	12.2	18.1	18.1	6.5	7.2	13.6	25.3	15	59.4	4.8	5.4	4.4	5	15	13.9	17	25.5	6.4	5.6	14.1	24.9	34.5	68.1	6.2	9.6	6.6	9	17.9	14.9	17	27.1	8.1	7.8
Winterthur	76	600	2	13	12.8		20.3	5.7	6.7	15.3	23.7	13.7		7.6	7.9	6.4	8.7																				
Winterthur	86	600	2	14.1	11.5				6.4	12.1	24.2																										
Winterthur	75	600	2	14	14.4	16.1	20.7	7.8	7.5	17.7	26.2	14.1	65.4	8.8	10.8	9	10.6	15.2	14.7	17.9	30.5	7.8	8.2														
Winterthur	14	600	2	13.8	13.5	15.9	17.9	5.8	6.2	13.2	24	15.4	51.2	6.4	8.2	6.2	9	13.8	13.1	17.9	27.7	7.4	7.3	14.5	23.7	29.2	76	5.6	8	4.8	8.5		15	17.8	27.6	9.3	10
Winterthur	17	600	2															15	13.6	17.7	29.8	7.8	7.1	12.5	25.4	30.9		4.9	7.7	5.3	7.4	16.8	15.3	17.4	32.9	9.3	8.2
Winterthur	94	600	2																																		
Winterthur	82	600	2																																		
Winterthur	30	600	2																																		
Winterthur	96	600	2																																		
Winterthur	83	600	1	14.6	14.9	14	16.9	6	6.5	16.6	22.9	13.8		6.4	7.4	7.6	6.9															17.6	16.2	14.8	28	7.8	8.5
Winterthur	18	600	3	13.5	13.6	16.4	18.8	5.8	6.2	17.2	24.1			6.1	10.4	7.9	8.7	14.5	14.4	17.6		6.9	6.5	15.9	24.4	28.9		7.4	12.8	6.2	11.2	17.8	17	17.6		11.4	10.6
Winterthur	5	600	2	13.5	13.6	14.3	18.4	6.2	5.6	17.6	23			5.6	5.2	6.1	6.4	14	11.8	17.8	27	7	7.5	15.2	25.9	30.1		4.5	9.5	5	8.3	16.2	16.3	16.4	28.5	7.8	7.1
Winterthur	7	600	2	13.1	12.9	15.6	16.8	6.9						7.5	10.1			15.8	15.7	15.1	25.7	7	5.8	16.4	27.5	30.8	99.6	7.2	8.9	7.7	10.2	18	17.7	15.5	23.8	10.6	9
Winterthur	116	435	2																																		
St.Johann	219	218	3	13.8	13.9					18.4	25.1		58.4	7	7.1			15.8	14.2	17	24.6	8.1	8.6	16	26.8			7	11.1	7.8	9.8	18.9	15.7	18.1	25.7	9	10
St.Johann	107	217	3	14	13.5	16.7	18.7	9.9	7.1	16.6	25.6	16.8	60.6	4.8	9.1	6.6	8.7	14.2	13.8	17.3	26.6	6.8	7.9	15.8	26.9	36.5		5.2	11.2	5.1	11.8	16.9	16.9	18.5	30.1	10	9.8
St.Johann	724	219	2															16.6	15.2	16.9	27.4	7	8.2	15.9	28.4			4.8	11.4	5.8	10.8	16.8	16.7	20.3	31.9	10.6	8.9
St.Johann	90	206	2	15.8	12.8	16.1	18.8	6.1	5.7	13.1	23.8		53.2	6.9	8.5	7	9.4	13.7	13.2	17.9	24.6	6.9	5.9	13.3	26.2		70.2	6.3	9.2	6.6	9	16.5	15.2	17	28	7.3	7.8
St.Johann	597	207	3	12.9	12.9	15.3	19.4	5.5	5.7		23		55.5	5.5	8.4	5.8	8.2	14	11.8	17.7	23.6	6.4	6.6	14.3	23.9			7	9.8	6.9	9.2	16	14.4	18.6		7.8	7.6
St.Johann	293	199	2	13.2	14	18.2	17.2	6.2	6.6	15	21.8		53.1	5.8	8.9	6.8	7.2	13.5	12	16.7	29.6	7.6	8.3	13.9	23.2	30.8		5.5	8.6	5.6	9	15.9	14.2		28.8	10.5	9.3
St.Johann	426	197	2	14.9	14.8	14	21.8	6.9	6	16.2	26			5.1	8	5.8	9.8	17.5	15.3	17.1	25	8.9	8.5	14.9	24.2			5.7	9.1	5.5	9.6	15.3	14.3	17.1	28.8	8.8	7.6
St.Johann	349	195	2	13.1	13.3	15.4	17.4	5.8	6.3	13.5	19.8		47.8	5.8	6.8	6.4	6.9			12.1	15.3																
St.Johann	275	195	2	13.9	13.8	16.6	19.9	6.2	5.6	18.1	24.6	12.7	56.6	6.3	6.8	6.1	8.2	14.1	13.5	17.4	27	6.4	7.5	17	27.2	33.8		6.9	8.5	7.5	10.9	16.6	14.9	17.3	30.6	7.3	6.9
St.Johann	83	194	2	14.1	13.6	15.5	20.3	6.9	7.2	14.8	25.5		59	7.4	7.7	5.8	8.1	13	11.8	17.8	28	7.1	6.3	15.1	28	23.1	69.2	5.8	9.3	6.1	8.5	16.7	15.1	16.5	30.5	7.5	7.6
St.Johann	210	194	2	13.3	12.9	13.4	18.7	6	6.7	14.6	24.2		51.2	7	9.1	7	8.2	13.9	13.3	14.9	25.5	6.4	6.3	13.4	25.3	25.7		7	9.4	7.1	10.6	16.8	14.7	14.5	29.8	8.5	8.2
St.Johann	14	192	1	13.6	13.9	15.2	17.1	6.4	6.5	15.3	23.8		60	6.6	7.1	6.2	6.1	14.8	14.2	16.9	25.9	7.2	8	13.2	23.8			6	8.9	6.6	8.1	17.2	15.8	13.6	25.6	8.2	9.2
St.Johann	94	180	1	12.1	14	15.8	16.7		6.9		21.8			7	6.8	5	6.8	15.5	15.2	16.4	25.1	6.6	7	12.8	23.5			6.6	9	6.1	8.6	18.5	16.3	17.6	27.6	9.2	8.8
St.Johann	345	186	1															14.6	13.2	19.9	27.2	8.7	9.8	14.7	27			5.3	8.8	5.4	8.9	16.6	14.8		32.2	8.8	9.9
St.Johann	9	184	1	14.5	13.8	14.8	16.9	6.9	7	19.2	26.8		55.2	8.7	8.9	7.2	8.1	14.2	13.2	16.5	24.2	6.4	6.9	15.3	28.8			8.1	11	8.1	11.3	16.3	15.1	17.4	27.1	9.3	
St.Johann	17	181	1	14	14.1	14.6	17.6	6.3	6.3	17.6	23.7	13.2		7.1	8.3	7.1	8.6	15.2	13.5	16.4	22.9	6.8	6.2	17.1	25.6	28.8		7.1	10.2	6.6	9.6	17.2	15.6	16.6	23.4	8.4	8.4
St.Johann	105	180	1																													15	14	15.3	30	6.7	5.4
St.Johann	8	179	1	13.6	12.3	15.2	17	6.5	6.6	14.3	21.4		53	5.8	6.8	5.1	7.3	12.2	10.1	17.4	23.9	6.5	6	10.6	25.4			5.2	6.5	5.5	7.5	14.4	17.6		26.5	7.8	7.8
St.Johann	278	175	1	13.2	13.6	14	16.8	5.5	5.4		25.3			7.8	8.2	7.7	8.3	14.8	12.5	15.2	25.7	7.1	7.1	18.2	30.3			8.5	13.5		11.3	15.7	15.4	15	27.5	7.4	7.6
St.Johann	432	173	1	10.5	11.8	14.9	20.1	6.3	6		22.1		52.2	7.5				12.2	10.2	15		6.2	6.8	14.2	24.4			6.6	11	7	8.8	14	13.2	16.6	25.6	7.8	7.5
"Geneva"	2	"	3	16.9	14.6		20.2	7.2	8.5	16.9	24.3			6.5		6.4		14.8	13.4	21.5	28.8	6.8	6.7	15.5	27.4	30.2		6.9	9.2	5.1	9.1	17	16.3	22	32.5	9.8	11.5
"Geneva"	18	"	3	16	16.4	15.5	21.5	7.8	8.2	15.8	26.9		64.4	7.6	9.3	6.6	8.5	15.7	14.1	19.9	26.4	7.4	6.8	14.5	26.5			5.8	10.4	6.8	10.9	16.8	16.3	17.8	33.9	7.9	8.7
"Geneva"	26	"	3	15.7	14	17.5	22.9	8.3	7.7	15.9	26.5			7.9	8.6	7.5	10.5															17.1	15.4	18.3	26.8	10.2	10.5
"Geneva"	6	"	3	14.7	13.5	16.6	20.2	8.5	8.6	15	25.5	21.4		7.6	8.7	6.4	5.7	15.5	14.7	18.3	27.7	6.6	5.4	15.5	26.4	32.9		6.5	12.8	6.7	11.9	19.1	15.5	21.2	32.8	8.9	9.9
"Geneva"	14	"	3	16.8	14.9	17.5	22.2	9.8		15.9	27.1	21		6.6				8.7	15	13.7	32.5		8.6	15.7	25.2	36.1			12.4		10.1	16.8	16.5		31.5	11.3	9.8
"Geneva"	3	"	3	13.9	14.1	18.8	19.2	7		15.9	23.8		55.8	5.6	5.9	4.2	4.5	14.5	13.8	18.7	27.1	7.8	8	13.8	25.6	26.8		5.4	8.1	5.9	8.4	16.8	15.6	20.9	29.5	10.8	10.9
"Geneva"	12	"	3	16.1	14.3	16.5	16.8	8.3		15.3	23.8		56.8	6.8	7.4	6.1	8.5	15.9	14.8	20.3	30.2	8.5	7.8	14.6	24.8	32.2			10.4	5.6	10.7	19.5	17.8	19.5	28.6	10.8	9.6
"Geneva"	1	"	3	14.2	14.8	18.3	23.3	7.5	7.8	18.2	27.1	14.6		7.6	11.8	8.3	10.8	16.1	13.2	17.1	29.6	8	8.8	17.7	28.1	33.6		7	11	7.6	10.2	17.8				9.6	8.8
"Geneva"	3	"	2	15.9	14.6	15.5	17.3	9.2	8.4	14.1	24.9			7.4	8.1	7.1	8.6	16.7	14.7	16.5	25.4	7.6	7.2	14.5	26.4	39.8		6.6	9	6.8	10.2	16.7	17.9	16	26.2	10.5	8.6
"Geneva"	9	"	3	15.3	15.2	16.8	19.8	8.3	9.1	16.2	23.2			6.4	9.2	6.3	9.2	14.8	13.7			7.6	8.6	13.5	24.5	31.2		5.6	11.1	5.5	11.5	17.8			28	10.2	10.9
"Geneva"	2	"	3	15.4	14	16.5	19.4			14.1	24.6	15.8		7.4	5.9		7.4	15.1	13.3	21.9	29.6		7.7	15.6	25.9	23.9			8.1	6.2	9.8	17.9	16.4	17.1	31.6	10.1	10
"Geneva"	5	"	3	15.3	14.7	16.7	17.6	8	8.1	15.6	25.3	19.4	57.8	6.6	7.7	4.6	8.3	16.7	15.7	18.1	25.7	9	8.8	16.5	26.4	35.3		5.1	11.8	6.3	12	18.2	17.3	19.1	29.2	11.8	11.8
"Geneva"	17	"	2	14.6	14.6	16.1	19.8	7.4	8.1	15.9	24.3		58.7	7.2	8.9	5.6	7.8	17	16	18.4	26.2	7.8	8.5	15.4	29.5	30.9		7.2	11.8	7	11.1	19.3	17.9	19.2	29.5	9.3	9.1
"Geneva"	6	"	2	16.6	16.8	17.6	19.8	8.8	8.3	16.7	24.7	17.8		7	10.1	7.1	9.1	16.2		18.7	24	10.4	9.2	16.5	22.7	37	82.2	7.3	11.4	6.8	10.1	19.4	18	18.7	24	10.4	9.2
"Geneva"	8	"	2	14.3	13.8	17.5	20	6.7	7.3	16.4	26.2	15.2		7.6	8.1	6.9	7.4	15.3	14.4	20	27.7	8.3	7.5	14.3	27.9	33.5		5	7.3	6.8	10.6	17	16.9	19.8	31.2	9.7	9.1
"Geneva"	13	"	2	15.7	15.8	18.6	20.6	8.3	8.9	14.8	24.1			6.3	7.6	5.9	7.4	16.7	14.8		29.3	9.6	8.8	14	27	30.7	72.4	6.8	8.9			18.9	16.4	21	35.9	10.7	8.6
"Geneva"	6	"	2	14.8	14.1	16.7	19.8	8.7	8.6	14.4	24.6	19.5	62	5.8	9.2	6.6	9.8	15.2	14	17.1	26.5	7.9	6.7	15.8	27.1	26	74.4	5.3	9.4	6.8	9.6	18.7	18.7	17.1	28.3	9.8	9.8
"Geneva"	9	"	1	16.7	15.6	16.8	21.9	6.9	7	16.2	26.3		57.2	7.6	9.3	8.4	8.6	16.2	15.9	15.8	25.2	8.1	6.2	17.2	26	34	70.3	5	10.5	6.4	11.8	18	17.8	17.4	27.6	9.9	8.9
"Geneva"	13	"	1	15.2	14.5	14	18.2	7.9	7.5	17.2	24.7		55.6	7.9	10.8	6.9	10.4	16.6		16.8	29.9	8.6	8.8	15.9	27.7			7.3	10.5	7.7	11	19.2	16.5	16.8	30.7	10.6	9.6
"Geneva"	14	"	1	15.4	14.9	14.8	17.6	6.7	6.8	16.4	24.6		55	7.2	9	7.8	8.3	15.2	12.8	16.5	26.8	7.8	7.6	15.5	25.9	32.9	25.6	6.3	10.6	6.8	11.2	17.9	15.9	15.4	25	9.5	9.8
"Geneva"	4	"	1	14.7	13.7	14.9	17.1	7.1	7	17.7	23.4			7.3	7.8	5.9	8.5	16.5	16.4	15.3	22.2	7.5	7.5	17	25.1			6.9	9.8	7.2	10.1	18.2	17.1	16.4	26	9.7	10.1

Individual / Sample	Specimen number	T1M10	T1M11	T1SPL	T1TPW	T1IFer	T1IFice	T1IFcr	T1IFrce	T6M2	T6M1	T6M5	T6M9	T6PHI	T6MH	T6M10	T6M11	T6SPL	T6TPW	T6IFice	T6IFrce	T10M2	T10M1	T10M5	T10M9	T10PH9	T10PH	T10M10	T10M11	T10SPL	T10TPW	T10IFice	T10IFrce	L1M2	L1M1	L1M5	L1M9	L1PH
LaFerrassie	1		22.5				9.9																											25.5			48	
LaChappelleauxSaints	1	14.9	25.6	35.2	72.2	5.6	11.1	6.7	12													21.7	19.7	29.1	38.3	16.3	14.8	18	17.5		56.4	10.6	12.7	27.2		29.4		15.4
CroMagnon	1																																	26.4	24.9	32.4	40.7	16.8
AbriPalaud	6																																					
Neuessing	2																																					
Veyrier	1																																					
LaBichon	1	14.8	23	28.2	68.3	7.3	9	6.4	8.5	19.2	17	22	21.9	9.6	10.3	16.9	18.2	16.6	62.2	9.7	10.9	21.1	24.2 21.4	27.7 25	35.2 27.2	18 13.1	17.2 13	18.3 18.1	20.7 20.4	25.5	56.2	14.3 13	13.4 14.5	28.2	27.2	26		14.6
Teviec	16	14	20	32.3	76.6	5.3	9.3	5.9	10	22	16.6	26.3	27.3	12.4	13.4	15.2	16.4	14.8	63.8	8.9	7.2													29.8	24.5	33.2	38.4	17.2
Gramat	1	14.2	21.5	30.5	77.1	5.5	9.3	6.8	9.6	21.8	21.5	22.9	26	11.6	12.2	17.4	17.9		64.4	9.7	11.4	23	22.6	26.7	33	14.5	14.3	15.3	17.8		62	19.6	10.9	28.7	24.6	28.8	39	16.3
Valhingen	8									21	19.2	22.7	27	12	12.9	16.4	17.4	14.6		12.8	14.4	21.7	22	27.7	31.5	13.6	14.7	15.2	17.9		55.6	11.2	10.6	28.3	25.9	28.6	39.8	17.2
Valhingen	18																																					
Valhingen	90																																					
Valhingen	7																																	27.7	22.2	32.4	39.4	
Wanderslaeben	2172																																	28.9	25.6	34.1	41.8	16.6
Wanderslaeben	2235																																		25.2	32.2	40.1	16.7
Wanderslaeben	2221																																	28.4	27.4	27.5	36.9	15.2
Wanderslaeben	2220	13.1	20.2		75.9	4.8	7.9	6.3	7.2	22.1	20.8	25	26.4	10.3	10.3	15.3	16.6	15.6	64.3	10.4	9	22.8	22.9	29.1	32.4	13.3	13.8	14.3	15.9	22.6	58.6	8.6	8.1	29.1	25.5	31.9	36.8	16.3
Wanderslaeben	2235																																					
Wanderslaeben	2165	14.3	22	30		6.9	10.4	6.9	9.3	18.8	17.5	21.3	25	10.3	9.7	15.7	16.2	14.3	61.4	9.4	9.2	22.3	21.6	25.2	30.5	14.4	13.5	15.8	17.8	19.6	60.6	12	8	27.1	24	26.5	35.9	14.3
Wanderslaeben	2126	14	20.6	35.1		4.8	6.2	5.7	6.8													21.9	20.9		35.5	15	15.8	14.5	15.5		63.3	8.5	10.6	27.8	23.4	36.1	42.6	15.1
Wanderslaeben	2219	14	18.4			4.2	9	4.8	8.2																									29.2	27.1	25.3		16.3
Wanderslaeben	2141																																	28.1	26	32.5	40.6	15.4
Wanderslaeben	2287	15	20.6	29.6		4.2	7.4	5.2	7.8	21.5	20.6	24.4	25.8	13.2	13.2	16	17.5		63	10.3	11.1	22.6	22.2	27.3	31.2	15	15.1	16.4	16.5	27.1	56.4	12.4	12.9	27.2	23.5	30.5	39.4	15.5
Wanderslaeben	2145									23.1				15.1	14.6	14.8	16.3	12.5		11.1	10.6																	
Wanderslaeben	2163									20.3	19.3	22.8	26.9	12.9	12.3	17.3	17.8			12.5	9.5	22.9	21.2	24.5	32.8	15.9	16.5	15	18.2	25.9	50.3	8.8	11.2	28.4	26.1	27.7	38.7	15.9
Wanderslaeben	2284	14.3	24.6			6		5		21.3	20.2	24.3	28.3	12	11.5	16	19.7			9	10.3	24.7	23.1	27.3	35.5	14.8	14.1	17.1	19	30		10.6	9.9	29.2	27		40.4	14
Wanderslaeben	2211	13.2	19.7	32	75	4.5	9	5	7.7	20.2	18.4	26.2	25.9	12.3	12.5	13.4	13.9	23	63.5	12.7	10	23.6	21.8	28.5	31.5	14.7	15	13.5	14.6	25	60	12.9	12.9	28.8	26.1	28.9	37.2	15.9
Wanderslaeben	2115	15.6	21	33			11.7		10.3	20.9	19.2	24.3	27.3	11.2	11.7	15.8	19.6	21.8		10.3	11.5	23.2	22.4	27.1	33.7	15.5	16.3	15.8	17.6	27	55.8	11.3	7.9	27.4	23.5	32.8	41.6	15.3
Hoabdic	9																																					
Hainburg	21125	13.4	19.4	37.4	77.2	5.5	9.9	5.8	8.2	18.8	18.3	24	24.2	11.6	11.4	17.8	17.8	23.6	63	9.5	10.6	21.2	21.9	27.8	32.2	13.8	14.1	15.4	19.5		56.6	13	11.8	24.2		38.2	15.1
Hainburg	21055	15.6	23.1	30.5	83.5	6.5	10.4	6.2	9.3													25.5	21.8	26.3	35.2	19.8	18	17.1	19.3	23.5		11.5	10.8	29.5	25.3	27.2	35.9	15.4
Hainburg	12145	15.6	22.2	30.5		5.8	10.4	6.1	9.9	20.8	20.3	27.6	30.6	12	11.6	16.7	17.3		66.4	11.6	14.1	24.5			38.4	17.4	18.8		16.6		63.6	7.2	9.9	28.9			39.9	13.2
Hainburg	13030	15	21.5	24.9	56.8	6.9	10.4	5.3	10.1	16.3			23.8	10.3	10.6	15.6	17.7			9.6	11.5	20.8	19.6	24.2	28.8	12	13.1	16.2	19.1	22.5		13.2	13.5	24.3	23.3	25.6	34.3	13
Hainburg	12144	14.7	18.5		79.2	5.3	9.2		10	19.8	18.5	23.5	28.2	13.2	13.6	14.2	17.3			11.6	13.4	21.5	20.8	33.6	34.7	13.5	14.1	15.2	16.2			13.9	15.1					
Hainburg	9706	15.8	21.9	33.5	73.6	5.6	8.8	6.8	9.6	19	18	21.8	29	12	11.5	16.5	16.9		61.6	12.2	10.5	21.3	20.6	27	34.6	15.5	16.1	16.4	17.8	22.4		14.1	13.2	28.6	25.8	27.9	37.6	16.8
Hainburg	21097	16.4	22.8	34.5	80.1	6.9	11.6	6.2	9.7	20.7	20.2	23	26.1	11.9	12.2	17	17.3	15.2	63.8	10.9	11.1	22.1	22.2	27.4	32.6	16.5	15.1	15.9	17.5	23.2	63.2	14.4	12.5	27.7	26	29.9	36.2	15.5
Hainburg	9887	15.1	20.8	35.4	77.2	6.5	10.5	5.7	10.8	20.8	19.6	25.2	29.7	11.4	12.2	15.9	15.5	16	62.7	10.9	10.2	22.2	22.4	30.2	35	14.5	15.6	15.6	17.3		53.6	8.1	8.2	27.8	27.5	30.3	38.6	16.5
Hainburg	12134	13.4	24.4	33.9	72.1		6.8	4.1	7.4													21.8	21.5	27.2	36.4			16.1	17.3	24.8		10.3	10.9	26.8	25.5	39.5	38.8	15.5
Hainburg	13053	16.4	22.6	21.1	80	7.9	12.2	6.4	11.9	20	18	24.1	27.6	10	10.1	16.5	16.2	21.1	60	9.8	11.9	21.4	20.8	29	32	12.8	13.8	15.2	19	29.8	65.3	14.2	14.6	28.2	28.3	27.6	37.6	13.5
Hainburg	12200	15.3	19.4	26.8	68.4	5.2	11.3	6.5	11.5	19.1	19.1	24.6	26.5	10.8	11.8	15.2	18.6	32.3		12.6	12.7	21.6	23	30.9	34.6	13.6	14.2	15.1	17.2	24.5	58.8	11.3	9.9	27.1	26.3	30.9	40.8	15.3
Hainburg	21115									22.9	21.5	24	29.3	13.8	14.1	17.4	18.7	22.7	62.5	11.8	12.3	25.5	23.2	29.2	34.1	18.6	17.4	18.3	18.6	22.6	47.8	11.4	10.6	25.8	29.6	30.3	40.6	16.8
Hainburg	13033	17.7	19.9	35.1	78.2	7.7	12	7.2	12	19	17.9	23	25.5	11	11.2	16.8	15.7		79.6	10.2		21.2	20.8	30.2	32.8	16	15.7	15.8	18.2	22	62.7	12	12.8	28.2	24	32.2	35.3	16.9
Hainburg	12143	14.2	20.3	26.3	75	7.3	9.6	6.4	10	18.2	17.3	21.8	26.8	9.7	9.5	13.7	16.5			12.1	9.8	21.2	18.5	28.5	32.8	13.8	14.2	13.9	17.6			11.2	11.8	27	23.2	29.5	39.9	13.6
Hainburg	13066									19.3	19.7	21.1	26.5	11.8	12	15	13.7			12		22.2	22.1	24.8	28.3	14.6	13.5	13.6	15	23.9		10.8	10.3					
Hainburg	9723	16.3	24.3	30.3	77.4	7.9	11.5	6.8	10.4	19.4	17.9	24.2	26.8	9.6	9.3	15.8	18.8	19	56.3	14.1	13	22	21.9	28.2	31.8	13.6	14	15.9	20.6		55.8	12.8	11.1	27.4	26.4	32.2	37.5	14.2
Hainburg	21091	12.9	24.6	25.8		5.6	9.6	5.5	11.4	20.2	16.9	24	27.9	10.5	9.8		16.8					22.6	21.6	27.8	33	14.6	15.1	15.2	17.7	20.3		11.4	12.7	30.2	27.9	30	39.2	18
Straubing	693	15.6	20.9	35.9	77.5	6.6	10.4	5.3	8.3	23.3	21.8	24.7	27.8	12.5	12.3	15.2	16.2		64.4	14	12	24.8	21.6	32.3	32.6	15.1	15.2	14.8	17.3	27.2	59.9	11.9	12.7	28	25.2	34.6	37.3	16.1
Straubing	606									21.4	18.7	26	26.3		12		17.6					21.9	21.9	31.6	32.4		13.7		20.5					26.8	25.7	33.6	41.2	14.7
Straubing	308	17.7	27.3	24.6		6.3	11.5	6.4	10.9	20.9	19.8	23.5	27.6	11.1	10.2	16.8	16.4	24.6		11.5	10.9	24	22.6	28.1	24.2	12.9	12.6	16.5	19.7	18.3	67.5	15.6	16.5	26.2	23.6	30.3	39.8	16.2
Straubing	766	14.9	21		75.6	7.2	10.5	6.9	10.2													25.4	24.1	25.3	29.6	15.3	16.1	17	18.2				11.6	25.9	22.6	25.2	32.9	14.7
Straubing	639	15.6	21.6		82.2	8.6	12.1	7.4	12.2	19.8	18.7	25.9	26.6	11.7	11.8	16	17.8		67.1	16.1	14.6	22.3	20.6	30.2	31.6	16.1	15.8	15.4	18.6	24.2	54.1	11.2	11.3	26.4	22.1	31.1	39.6	14
Straubing	491	14.8	21.6		73.7	6.3	11.8	7	10.6	22.6	20.1	26.8	28.2	13.6	13	17.3	14.8			15.4	14.2	23.1	20.3	27.7	34	15.8	16.2	16	17.5			14.5	12.5	28.1	23.2	29.6	35	16.4
Straubing	373	14.3	23.1			6.2	9.8	6	10.4	22.6	20.8	26.6	29	13.6	13.8	16.8	19.3			10	11.2	25	22.1	28.2	33.6	17.5	16.8	15.8	18.8		46	11.4	9.5	29.1	24		43.2	14.1
Straubing	368		21.4			7.9				23.3	21.5	25.1	26.5	13.6	14.2	16.9	17.2	18.5	71.5	10.2	11	24.2		29.2	34.8	14.5	15	16.4	19.3		69.8	11.2	12	29.4	25.8	29.8	39.8	16.3
Straubing	275	15.3	21.4		70.4	6	8.7	7	11.4	19.7	17.4	24.1	25.6	11.6	10.1	15.2	17.6		63	14.8	15.8	20.1	19.7	28.6	33.8	13.9	13.7	15.1	17.7	28	57.7	10.2	11.2	25.4			42.8	13.6
Straubing	626	14.6			74.3	6.1	9.8	6.2	8.9	20.1	18.1	26.6	30.3	12.4	12.9	16.2	16.1		68.1	12.2	11.4	24.1	23.3	29.8	36.4	14.8	14.8	15.4	17			9.2	9.3	28	24.1	34.5	43.9	16.5
Straubing	433	15.4	22.6	32.2	73.2	7.7	11.5	6.6	11.3	19.6	17.3	22.5	26.2	9.8	11.3	17.1	18.5		59.2	10.9	9.8	25.3	22.5	26.7	31.2	13.9	14.1	16.8	19			13.3	10.8	27.1	25.1	30.6	39.2	13.6
Straubing	745	14.5	21.8	36.2	76.8	5.8	9.6	5	10.5	22.2	18.2	24.5	30.8	13.4	12.8	16.5						26	20.9	34.6	36.6	15.6	17	15.3	19.2		68.6	12.8	13.1	28.8	28.4	33.3	42.3	15.6
Straubing	363						12.2		13.2	22.9	19.8	27.5	30.7	11.8	12	18	18.8					25	23.5	31.2	38.2	16.1	15.6	17.7	20.6			14.8	16.1	29.2	28.4	30.1	44.3	15.2
Straubing	501	16.8	22	29.3	84.3	7.3	11.5	6.8	12.5	23.1	21.2	22.8	25.2	13.3	12.8	16.1	17.3			9.4	10.6	23.6	23.2	28.7	32.5	12.87	13.6	16.9	18.2					29.5	27.8	31.1	41	15.3
Straubing	272	15.9	25	34		7.5	10.9	6.7	10.5	20.2	18.9	23.4	30.3	13.1	13.1	15.5	18	12.5	65.6	12.8	12.2	22.6	20.5	28.8	35.2	15	14.9	15.8	19.9		63.6	14	12.5	30.3	27.7	30.4	43.4	18.4
Straubing	636	17.5	24.4	31.2	75.8	7.8	10.8	7.1	10.6	21	19.2	23	26.8	11.2	12.8		21.1					25.4	22	28.2	33.8	15.2	14.5	19.8		20.5	62.6	14.4	12	27.3	23.5	28.3	40.8	14
Straubing	412	14.3	22.9	21.2	68.3	5.6	9.9	4.6	9.8	17.3	17.4	21.6	26	8.8	9.3	15.6	17.6			13	11.7	19.4	18.3	27.6	32	13	12.6	15.8	17.8			12.5	13	24.2	21.9	27.3	35	12.8
Straubing	605									21.2	18.5	25.1	26.2	12.1	12.2		17.7					21.5	20.8	31	30.9									25.4	22.2	31.6	40.4	16.4
Straubing	280		22.2		83.3	8.1		7.5		20.9	18.6	27	30.2	11.8	11.7	15.4	16.5	14.5		14.3	13.5	24.2	21.2	31.9	35.9	15.1	14.5	15.8	17.2	24.2	51.4	13.6	11.8	28.2	25.3	34.3	41.4	16.5
Straubing	469									22.9	20.6	26.5	26	12.2	11.8	17.6	19	18.8	73.9	11	11.6	22.5	22.8	31.1	34.8	14.7	14.8	15.9	17.6	28.1	60.7	14.5	13.9	32.1	28.3	32.2	42	14.8
Straubing	500	14.6	21			6.3	8.6	6.4	8.8	19	18.2	22.2	24.1	10.2	10.1	14.8	16.2			13.6	13.6	22.2	21.5	25.2	30	13.8	14.3	14.5	16.7			12.5	13.6	27.6	23.3	26	33.6	12.1
Straubing	640									22.6	19.8	26.8	29.7	12.8	14	17.2	19.2	22.6		15.1	13	26.4	25	32.7	39.9	19.4	19	17.2	20.5			12.4	11.6	29.7	25.5		46	17.3
Straubing	418	17	22.6	24.8	81.4	8.5	12.9	8.5	12	17.3	15.1	25.8	22	10.6	11.7	16.3	14.5	16.8	48	11	10.2	22.6	21.6	27.2	27.6	14.6	14.2	17.5	17.8			13.5	12	27.8	24.2	27.1	32.6	14.2
Straubing	370	14.6	23.5		76	6.6	10.6	5.2	9.3	21.1	19.4	24.8	26.2	14	13.2		15.4					23	20.3	27.2	29.7	13.5	12.6	15	15.2	24.1	56.2	12.9	12.2	29.9	27.1	26.7	39.3	14.6
Straubing	731	15.4	21.8	30.6	82.6	6.8	10.5	7.2	9.8	21.5	19.6	27.1	29.5	12.1	14.4		14.5					22.6	19.2	33.8	37.2	14.5	15.9	15	15			12.1	12.4	26.1	23.9	34.9	40.5	14.9
Straubing	763									19.6	17.1	26	27.3	11.6	12.2	15.1	16.1		64	11.4	11.2	21	19.5	28.6	31	13.8	13.4	14.6	17.1		58.8	12.6	12.9	26.7	24.8	28.5	38.7	15.6
Straubing	806									21.4	18.9	27.6	29.2									25.6	23.6	29.1	37.9									27.9	24.2	32.2	44.1	16.2
Straubing	765									20.6	19.3	24.3	30.3	10.3	11.5		18.5					25	22.8	32.3	36.2	15.5	15.2	17.2	19.5		66	13	14.4	29.1	26.2	37.8	43.6	15
Straubing	493																																	27	27.5		42.6	15.9
Straubing	438	13.8	21.5	31		5.8	8.5	5.1	8.5	20.1	17.2	22.6	26.5	11.9	13.1	14.4	16.9		60.5	11.4	11.5	24.1	22.8	25.1	32.4	16.6	15.1	14.7	16.4	23.8	56.9	9.8	9.5	28.8	27.1	29.6	37.7	15.5
Straubing	656									21.2	18.4	27	28.2	12.5	12.2		16.3					25.1	23.8	28.8	38	17.7	16.1		21.6					27.3	24.2	32.4	43.3	16.7
Straubing	301	14.4	19.6			7.6	9.5	6.5	10.2	22.8			24.8	12.1	12.6	14.8	15.9		63.6	12.6	12.3	23.9	21.3	30.6	30	14.4	16.2	13.8	16.7		60.9	13	12	26.9			34.7	15
Straubing	575	15.7	22.1	32.9	76.1	7.2	11.8	6.8	11.5	21.4	18.2	26.8	28.9	11.6	11.2	18	19.3		66.6	13.1	13	23.5	22.3	31.6	36.1	14.6	14.4	19.1	19.5	28.3	58.5	14	12.6	28.2	25.9	31.1	45.8	14.1
Straubing	356	15.6	21.6	33.3	78.6					20.2	18.6	26.4	28.2	12.6	12.8	15	16.3	10.7	64	11.6	11.1	23.9	22	29.5	34.8	15.9	16	16.2	16.4	12.7	46.8	13.5	10.8	26.6	25.9	32.2	42.5	15.7
Straubing	378	15.5	21.7	30.7		6.9				19.6	16.8	26.4	26.7	11.1	10.8	15.4	17.5			14.2	13.8	22.5	22.4	31.9	34.5	14.9	15	16.7	18.9		60.4	10.2	11.8	26.6	25.5	33.2	41.1	14
Straubing	296	15.4	22.5	31.9	85.2	7.7	10.5	6.5	10.9	22	19.8	25.5	30.8	11.8	10.7	16.5	19			9.8	11.9	24.9	23.8	28.9	35.9	16.4	16.2	17.3	18.2			14	14.3	28.6	29	31.5	40.2	15.4
Straubing	791									19.9	18.2	25.8	28.9	11.2	10.9	15.1	16.1			12.9	11.5													25.7	23.7	33.8	41.4	15.4
Asach	23	17.6	25.7			5.8	11.5	6.7	11.8																													
Asach	4	16.2	21.8	35.2		6.2	10.6	6.5	11.4													23.9	22.1	29.9	35.5	16.1	15.5	17.6	18.2	27.7	67.2	11.2	10.6	26.7	23.6	31.5	44.2	13.8
Asach	35	17.2	20.3			5.2	6.8	5.3	10.2	21.6	18		27.4	11.4	12.3	16.7	16.6			8.2	10	24.7	19.9	28.9	36.9	16.4	16.4	16.2	20.5		51.4	12.6	11.9	26.4			42.5	14.9
Asach	12																					25.1	24.5	29.7	32.9	16.1	14.6	17.4	20.6			13.2	11.3	30	26.5	34.2	43	16.9
Asach	29																																	26.4	24.4	27.6	41.3	
Asach	36	14.2	27.7			6.2	9	6.2	8.8	21.8	19.5			13.2	13.9	17.6	19.5		74	13.5	11.9													26.6	23.7		39.5	
Asach	19	14.8	20.6			6	10.2	5.8	10.1	22.5	19.6	26.8	28.8	11.2	11.7	15.6	14.2			11.5	11.9	24.5	22	33.8	34.1	14.7	15	15.3	15.5			10.9	11.5	28	25.2	34.5	37.3	14.8

Individual / Sample	Specimen number	T1M10	T1M11	T1SPL	T1TPW	T1IFlcr	T1IFlca	T1IFrcr	T1IFrca	T6M2	T6M1	T6M6	T6M9
Aesch	49	15.6	23.4		89	5.4	10	5.6	10.8				
Aesch	10												
Barbing	1355	14.8	22.4		85.6	5	8.6	5.5	10.2	23.2	21.2	25.7	32.4
Barbing	1359	16.6	21.8	32.6	87.5	5.2	8.5	5.1	8.8				
Barbing	1280	13.8	18.3		86	5.4	8.2	5.4	9.5	22.3	19.2	28.5	
Barbing	1340			20.7	80.6	5.3	7.8	5.2	8.2	19	17.3	28.6	30.1
Barbing	1373	15.6	19.3	38.5	83.3	7.8	11.6	7.6	10.6	21.8	18.4	27	29.3
Barbing	1330	15.6	21.9			5.8	10	6.1	9.8				
Barbing	1326	15.3	21.3		76	6.2	9.6	5.8	8.4	18.2	17.6	24.4	26.2
Barbing	1379	17.2	24.6		81.9	5.9	11.4	6.8	10.5	22.9	22.2	29.8	31.7
Barbing	1294				92.2	6.5	11.4						
Barbing	1371	14.5	19.5		76.5	6.1	8.6	5.8	11.2	18.2	17.3	29.6	28.4
Barbing	1266	16.2	25.1	34.8	80.9	5.1	8.2	5.1	7.8	20.4	18.4	27.5	28.2
Barbing	1395	14.1	21.8		75.1	7.1	8.7	6.8	9.5	22	19.7	28.7	32.3
Barbing	1288	13.6	24	23.1	50.2	5.4	8.3	5.9	7.5	19.2	17.6	23.5	27
Barbing	1277	15.7	22.6		75	6.7	8.8			22.1	18.3	23.5	27.7
Barbing	1289	16.6	19.6		82.8		11.7		10.9	23.1	19.8	25.1	28.8
Winterthur	6	15.5	22	32.1	77	6.1	8.8	7.1	10.1	22.4	20	24.5	27.2
Winterthur	141									22.1	20.2	27	26.7
Chur	66	15.9	23.6	35.8	84	6.5	10	6.9	8.4	22.3	18.1	29	31.8
Chur	46	14.5	22	30.3	76.6	4.9	7.8	5.1	8.8	18.7	18.4	24.4	28
Chur	63	15.8	23.4	35.1	86.8	6.3	11.5	6.6	11.2	21.2	18.8		30.5
Chur	40	15.8	22.3	28	77	6.2	11.3	5.7	11.5				
Chur	533												
Chur	30	13.7	21.7		71.2	4.6	7.2	5.4	8.4				
Chur	408			32	87.5	5.3	8.3	5.1	9	20.6	19.3	31	29.5
Chur	31												
Winterthur	84	16	17.6		73.2	6.5		6.8					
Winterthur	24	16.9	26.5	32	82.8	7.5	12.1	6.7	10.6	23.2	20.2	27.5	27.2
Winterthur	80				71.5	6.5							
Winterthur	51	14.5	20.7	32.8	77.3		10.2	5.6	9.4	22.2	20.5	25.2	29.1
Winterthur	79	15.2	22.8	29	72.6	6.1	7	4.5	8.7	23.2	21.8	25.4	26.1
Winterthur	90	14.8	20	25.2	73.6	5.2	8.6	4.7	10.5	18	18	22.4	26.4
Winterthur	72	15.4	21.6	34.6	73.8	6.3	9.5	6.5	9.4	21.6	20.2	25	26.2
Winterthur	76												
Winterthur	86	16.1	23.5	31.4	84	6.1	10.4	6.1	10	22.4	20.1	30.1	30.8
Winterthur	75												
Winterthur	14					5.8	9.2	6.8					
Winterthur	17	14	24.4	30.4	77.3	5.6	8.6	5.5	8.7				
Winterthur	84												
Winterthur	92												
Winterthur	30												
Winterthur	96												
Winterthur	83	15.8	22.6	34.8	78.6	6.8	9.6	6.5	9.8				
Winterthur	19	16.7	22.2	33.5		8.1	13.2	6.3	12.4	23	17.8	29.4	29.3
Winterthur	5	15	23.8	28.8	78.4	6.9	10.4	6.2	9.5				
Winterthur	7	15.8	22.2	36.5	74.8	6.6	11.3	6.2	10	20.9	19	26.8	27.6
Winterthur	116												
St.Johann	219	16.1	22.4			7.3	10.6	5.6	10.6	20.9	17.2	27.1	25.2
St.Johann	107	16.4	22.2		85.9	4.6	10.8	5.7	9.8	21.5	16.5	29.6	29.1
St.Johann	724	15.2	24.8		88.9	5.3	11	6.5	9.5	21.1	19	32.3	31.7
St.Johann	90	14	22	32.3	73.8	6.4	9.9	5.1	8.2	20.1	17.7	25.5	26.6
St.Johann	597	15.3	23.2		78	6.5	9.1	6.1	9.8	20.2	18.7	25.5	25.2
St.Johann	293	15	21.5		80.6	5.1	10.5	5.6	9.8	19.7	19.8	27.3	28.8
St.Johann	426	13.7	27.5			6.8	9.9	6	8.1	21.6	20.4	25.5	28.2
St.Johann	349												
St.Johann	275	16.7	24	33.5	76.8	6.8	8.5	8.2	10.5	21.6	19.6	24.3	25.2
St.Johann	83	16.1	24.1	31.8	80.2	7.3	8.8	6.7	9	20.1	18.6	25.7	26.6
St.Johann	210	15.1	22.2		73.1	5.5	11	5.7	11.3	20.5	19.5	21	27.3
St.Johann	14	14.5	21.6			5.5	8.9	6.4	8.2				
St.Johann	94	14	20.3		70.8	6.6		5.7	9.6	21.2	20.2	28.5	28.2
St.Johann	345	16.1	22.7		81.8	6.9	9.8	6.1	9.2	22.3	22.1	27.3	31.4
St.Johann	9		24.2		76.2	7.2	12.8			19.8	17.1	26.2	26.2
St.Johann	17	16.2	19.5		73.2		13.9		13.9	21.6	20	24.8	27.2
St.Johann	105	15.6	22.9		69.8	6.3	11.4	7	10	21.5	20.8	24	27.8
St.Johann	8	12.7	21.4		75.9	4.8	8.2	5.1	7.2	16.3	16	22.4	26.2
St.Johann	279		27.7		78.2	8.8	12.5		12.1	19.2	16.8	23.2	25.8
St.Johann	432	15	19.8		71	5.8	7.6	5.6	8.3	18.4	15.2	21.2	23.6
"Geneva"	2	14.8	24.3	36.9	82.9		10.5		11.2	19.8	18.4	27.8	29
"Geneva"	18	16.3	23.8		82.9	7.3	11.4	6.3	12	22.9	20.3	25.6	29
"Geneva"	26	17.4	25.2	30.1		8.1	12.6		12.1	20.6	17.5	27	26
"Geneva"	6	16.6	23.9	32.6	82.3	7.3	13.3	7.5	13	22	19.2	25.5	26.1
"Geneva"	14	16.5	22.6	36.3	86	5.8	10.7	6.1	11.2	22.4	19.1		30.9
"Geneva"	3	13.8	23.6	28.8	72.7	5.3	9.3	5.3	9.1	21.2	20.2	26.9	30
"Geneva"	12	16.4	21.7	33.7	78.2	7.5	11.8	7.1	11.3	20.2	18.5	28.6	28.1
"Geneva"	1	18.8	25.2	37.5	84.5	7.7	12.8	8.8	12.1				
"Geneva"	3	15.7	23.5		74.8	6.1	10.3	5.8	10.6	21.1	20.5	26.7	31.7
"Geneva"	3	15.2	22.8	37.6		6.5	11.8	5.4	10.7				
"Geneva"	2	15.5	24	23.9	76.1	4.9	11.4	7.3	11.1	21.6	21.4	25.2	26
"Geneva"	5	17.7	25.4	36.2	85.7	6.7	13.2	8	13	21.2	17.7	27.8	28.1
"Geneva"	17	17.6	25.8	34.3	86.2	8.1	12	7.5	11.4	21.4	20.2	30.9	30.3
"Geneva"	6	16.5	22.7	37	82.2	7.3	11.4	6.8	10.1	21.6	17.4		32.2
"Geneva"	8	15.8	24.4	36.2	79.7	5.8	8.8	6.3	10.9	21.8	20.6	25.9	27.6
"Geneva"	13	14.8	23.6	28.5	82.8	6.4	9.9	6.1	9.3	24	21.4	29.5	29.1
"Geneva"	6	17	23	30.1	82.5	5.8	10.5	6	11	22.5	20.5	25.2	26.2
"Geneva"	9	16.2	23.2	34.9	85	7	12.4	7.1	11.8	21.5	17.7	26.7	30.6
"Geneva"	13	16.5	24.3		74.6	7.9	12.4	8.4	12	22.4	18.8	26.8	29.5
"Geneva"	14	16.1	21.5	31.5	75.6	6.8	10.7	7.3	11	20.5		24.7	23.8
"Geneva"	4	16.4	21.8		78.3	7.3	10.5	7.2	10.9				

Individual / Sample	Specimen number	T6PHl	T6PHr	T6M10	T6M11	T6SPL	T6TPW	T6IFlca	T6IFrca	T10M2	T10M1	T10M6	T10M9
Aesch	49									27.2	24.8	32.2	36.3
Aesch	10												
Barbing	1355	12.3	12.8	16.2	16.8		71.6		8.5	24.6	24.1	32	38.6
Barbing	1359									27.8	22.4	34.8	36.7
Barbing	1280		13.5							24.6	23.5	32	37.3
Barbing	1340	11.8	10.2	16.3	18	21.1		13.2	9.8	25.4	21.6	32.5	38.8
Barbing	1373	11.9	13	16	16.1		67	8.6	8.7	24.6	23.2	31.3	35.5
Barbing	1330										21.7		33.2
Barbing	1326	11.1	11.8	15.9						22.8	21.4	27.3	31.9
Barbing	1379	9.8	10.6	18.1	19.6		68.1	12	10.2	24.8	22.2	35.8	38.8
Barbing	1294												
Barbing	1371	11.8	12	14.3	15.2		64.2	8.1	8.9				
Barbing	1266	11.2	11.1	17.6	18.2	22.3	74.8	8.3	10.5	22.5	22.1	32.8	36.4
Barbing	1395	12	11.4	15.3	17.8			9	8.7	25.5	24.4	32.5	36.7
Barbing	1288	10.5	10.2	13.8	14.2		63.1	7.5	8.8	22.5	21.8	26.8	29.8
Barbing	1277									24.4			
Barbing	1289	12.8	13.3	16	18.3	10.3	70.2	10.1	7.8	24.2	23	29	35.6
Winterthur	6	12.8	12.1	16.7	18.5		72.6	11.4	11.9	25.8	23.6	29.8	35.7
Winterthur	141	13.6	13.6	14.5	16.6		61			24	24.3	31.5	33.2
Chur	66	13.4			16.8					24.3	22	35.5	39.5
Chur	46	10.6	11.3	16.3	18	18.2	65.7	6.6		21.8	21.6	25.4	34.8
Chur	63	12.7	13.7	17.9	17.6					23.5	22	34.7	38.2
Chur	40												
Chur	533									25.1	23.6	30.6	35.4
Chur	30												
Chur	408	13.5	12.6	14.7	17.3			11.5	11.7	24.1	23.2	33.1	37.8
Chur	31												
Winterthur	84									25.9	26.8	30.9	33.7
Winterthur	24	13.6	12.9	16.3	16.1		61.8	12.2	11.9	25.1	21.8		34
Winterthur	80												
Winterthur	51	13.8	14.5	16.1	16.6			11.8	13.1	24	22	32.6	35.8
Winterthur	79	11.5	12.8	15.5	16.9	29.6	63	9.8	9.8	25.4	25.9	27.4	31
Winterthur	90	10	10.4	16.5	15.2	29.9	58.6	11.4	11.8	22.5	22.6	26.6	25.2
Winterthur	72	13	14	17.6	16.8		70.1	11.6	11.6	25.3	26	31.8	33.6
Winterthur	76												
Winterthur	86	13.3	13.2	16.1	17.7		61.9	11.4	11.9	26.3	24.4	33.8	
Winterthur	75												
Winterthur	14												
Winterthur	17									23.2	22.4	31.4	37.2
Winterthur	84												
Winterthur	92												
Winterthur	30												
Winterthur	96												
Winterthur	83									26.7	24	31.3	33.5
Winterthur	19	12.4	13.8	17.2	17			12.8	8.8	26	24	35.1	37
Winterthur	5									24.1	22.2	27.3	35
Winterthur	7		11.3		18					22.5	21.8	30.4	35.5
Winterthur	116												
St.Johann	219	12.9	12	14.8	16		59.3	11.9	12.2		20.8	28.8	33.4
St.Johann	107	12.2	13.2	17.4	17	13	75.6	10.5	12.2	23	17.8	26.8	40.2
St.Johann	724	11.5	12.5	15.2	19			14.1	13.3	25.4	23		39.2
St.Johann	90	9.8	11.5	14.9	17.1	17	66.2	9.3	11.8	24.5	23.2	28.8	34.3
St.Johann	597	10.7	12.2	17.1	17.9		61.8	15.3	14.1	23.9			34.8
St.Johann	293	11.2	11.8	18	16.5		66.9	15	14.3	21.3	22.5	31.1	25.2
St.Johann	426	10.9	12	19	19.9		68.1	13.2	11.6	24.4			35.9
St.Johann	349									22.6	18.8	33	36.6
St.Johann	275	10.8	10.9	17.8	19.1	14.2	62.6	16.2	13.1	24.8	23.6	28.8	30.2
St.Johann	83	12.2	12.6	16.6	18.4		63.2	13.8	12.6	23.8	20.8	31.7	33.1
St.Johann	210	12.3	11.8	17.6	16.4		58.6	13.3	12.4	25.3	24.8	28.8	35.2
St.Johann	14												
St.Johann	94	11.4	11	14.7	16.2		64.4	13.6	13	24			31.5
St.Johann	345	12.2	14	17.8	18.7					24.8	23.6	34.3	38.5
St.Johann	9		13		18.5					23.2	20.9	31.3	33.7
St.Johann	17	10.6	10.6	16.2	19.5		67	13.9	13.9	22	20.6	30.5	31.9
St.Johann	105	11.1	11.8	16.8	17.5		55.5	14.2	13.7	23.2	23.6	29.3	30.5
St.Johann	8	10.5	11.2	14.5	13.8		58	10.6	9.8	22	21.9	27.5	30.4
St.Johann	279	10.5	11.4		21					25.5	24.3	24.6	
St.Johann	432	12.1	11.4	16.8	16.1			10.8	11.4	18	19.8	30.8	27.9
"Geneva"	2	13.6	14.1	17.5	18.5	18.6		14.4	13.8	23.3	22.2	35.3	36.3
"Geneva"	18	12.8	13.4	17.6	16.1		65.6	15.2	12.5	23.5	22.9	32.2	35.8
"Geneva"	26	11.9	12.9	19.5	19.5	10.5		13.2	13.8	23.1	21.5	28.9	32.4
"Geneva"	6	12.5	12.4	18.5	18			11.7	10.6	22.9	23.6	32.8	35.8
"Geneva"	14	13.4	13.1	16.9	17.2			15.6	12.6	23.8	22.9		37.6
"Geneva"	3	13.5	13.8	15.5	16.3	16.4	64	13.6	13.7				38.7
"Geneva"	12	13.8	13	16	17	26.4	66.5	16.6	13.2	25.1	24.1	34.2	36.6
"Geneva"	1									25.3	22.8		39.8
"Geneva"	3	11.9	13.6	15.7	18.2		64.6	12.8	13.7	26	23.2	29.7	35.4
"Geneva"	3									23.5			36.3
"Geneva"	2	12.8	13.3	16.5	17.4		65.2	14.5	12.6	24.2	21.9	32.4	36.3
"Geneva"	5	13.5	13.5	16.9	18	14.3	68.4	12.2	11.7	24.5	21.2	35	37.4
"Geneva"	17	12.5	12.6	15.2	18.1	24.1	73.4	12.8	12.5	23.2	22.5	36.1	36
"Geneva"	6	12.6	13.1	15.6	17.4	25.7	64.3	11	9.7	24.5	22.8	36.8	36.7
"Geneva"	8	12.8	12.9	18.4	18.7		67.4	14.6	15.5	25.1	23.8	31.6	36.8
"Geneva"	13	14.8	14.9	15.8	16.1	17.6	69		13.6	25	21.9	38.2	36.1
"Geneva"	6	13.3	14	16.8	16.1	18.3	70.7	12.4	11.2	25.3	22	30.6	33.6
"Geneva"	9	12.2	13.3	16.5	16.8		66.6	13.1		24	22.1	31.8	35.8
"Geneva"	13	12.6	12.1	16.4	19.7	27	66	12.4	12.2	23.9	21.8	24.5	32.8
"Geneva"	14	11.8	11.2	16.1	16.9		69.7	15.1	13.1	23			27.7
"Geneva"	4									24.7	22.9	32.6	35.3

Individual / Sample	Specimen number	T10PHl	T10PHr	T10M10	T10M11	T10SPL	T10TPW	T10IFlca	T10IFrca	L1M2	L1M1	L1M6	L1M9	L1PHl
Aesch	49	18.1	16.5	16.8	17.9					31.9	30.5	31.8	42.5	17.7
Aesch	10													
Barbing	1355	17	18.4	16	16.8		61.2	10.3	10.1	30.5	27.9	35.4	44.8	18.6
Barbing	1359	18	18.8	17.1	17		60	13.7	10.5	28.4	29	33.8	44	15.8
Barbing	1280	17.2	16.5	13.7	15.2	30.6	59.2	11.2	12.1	28.8	27.5	32.8	44.4	15.1
Barbing	1340	16.3	17.6	18.9						29	26.5	36.5	42.8	15
Barbing	1373	16.2	17	16	17.3			8.5	8.6	29.5	27.9	32.8	38.2	16.7
Barbing	1330									26.9	26.3	33.1	38.5	14.2
Barbing	1326	15	13.6	15.7	16.5		63.4	11.3	11.3	25.8	22.8	30.4	38	14
Barbing	1379		14.4	15.2	20.9				9.8	27.8	26.5	37.6	42.8	18
Barbing	1294									32.7	28.9	32.6	37.2	
Barbing	1371									26.8	23.4	31.8	38.2	14.9
Barbing	1266	14.9	16.3	18.2	20.3	28.4	72.2	8.7	8.1	27.2	24.7	32.5	39.5	16.4
Barbing	1395	15	14.8	15.4	17.8		56.8	10.2	10.1	28.9	26.9	34.8	38.8	14.3
Barbing	1288	15.2	13.8	14	15.9		55.5	10.3	12.1	25	23.5	28.3	35.6	15.3
Barbing	1277	15.7			22			12.4		28.2	26.1	31.5	38.4	14.5
Barbing	1289	16	16.2	16.8	18.1		59.5	8.6	8.3	28.5	28	28.7	40.6	15.7
Winterthur	6	14.1	15.6	16.4	18.2	31.5	65.1	12.8	12.3	28.6	28.5	31.9	41.2	17.4
Winterthur	141	14.6	15.4	15.8	17.3	29	59.8	13.3	11	27.7	22.9	33.7	38.6	17
Chur	66	16.8	15.3	14.5	17.8					30.1	28.2	26.3	41.4	17.9
Chur	46	14.6	14.8	15.8	20.2	25.2	55.5	9.6	8.5	25.3	24.3	29	42.2	15.6
Chur	63	16.6	15.9		20.7									
Chur	40													
Chur	533	15.2	15.5		22.6		69.1	16.4	15.9	27.6	28	32.7	41.3	16.4
Chur	30													
Chur	408	15.3	15.3	15.2	18.9			12.6	11	28.8	26.3	34	43.1	15.2
Chur	31									29.2	27.1	31.8		
Winterthur	84	16.1	17.1	15.9	18.8	30.8	60.8	13.2	13.2	28.8	29.3	34	42.8	14.7
Winterthur	24	15.4	14.2	15.9	18.2		68.2	13.7	12	27.3	26.2	33.5	42.8	13.6
Winterthur	80													
Winterthur	51	16.5	16.1	14.9	18.7	29.8	54.6	9.3	10.4	27.6	27.1	31	43.6	18.2
Winterthur	79	15.5	13.8	16.7	18.9	34.5	57.6	11.8	12.5	29.6	28.4	29.4	37.6	18.5
Winterthur	90	15	15.9	14.8	16.3			12.2	12.4	27	28	27	41.6	15.5
Winterthur	72	17.1	16.8	18.7	20.8		51.6	12.5	11.6	30.7	23.2	36.3	42.2	15.8
Winterthur	76													
Winterthur	86	16.8		16.2	21.7	35.4		12.8	13.2	27.2			42.6	16.3
Winterthur	75									27.8	26.4	32.8	42.2	13.8
Winterthur	14													
Winterthur	17	15.2	14.8	14.8	18.7	25.8	67.6	12.4	10.4					
Winterthur	84									27.2	24.3	30.1	35.7	13.8
Winterthur	92									30.2			45	16.7
Winterthur	30									39.8	27.2		38.5	17
Winterthur	96									27.2	27.4	26.1	40.4	14.8
Winterthur	83	16.8	16	18.8	21.1			12.4	12.2	28	25.9	28.5	30.3	15.9
Winterthur	19	17.3	17.3	16.9	18.3			14.5	13.3					
Winterthur	5	15.5	15.1	15.8	18	24.2		13.3	12.7	28.5	27.8	30.2	39.2	14.2
Winterthur	7	14.9	15.5	16.5	18.1	27.9	54.6	11.4	12.5	27.8	26.6	30.1	38.9	14.3
Winterthur	116									30.3	27.7	30.2	37.5	
St.Johann	219	14.9	14.6	16.3	16.8		64.4			28	26.5	31.1	37.9	14.5
St.Johann	107	15.3	15.5	16.3	19.6		65.6	14.8	12.5		27.8		45.9	16.4
St.Johann	724	16.4	16.1	17.2	20			15.1	14.4	29.8	27.2	27.6	46.2	18.8
St.Johann	90	16.2	16.4	13.4	17.6			10.6	12.4	29.5	25.4	30.5	41.2	15.2
St.Johann	597	13.9	14.5	15.1	18.4		60.8	11.4	10.2	27.4	27.4		38	15.3
St.Johann	293	14.3	15.8	15.5	16.2		61.7	12.8	12.5	26	23.5	34.9	43.8	17.5
St.Johann	426	14.5	15.1	18.5	21.4			13.9	14.2	29.8	27.4	31.5	41.8	17.1
St.Johann	349	16.5	17.2	13.2	15.8		54.2	9.7	9.1	22.7	26.1	28.5	45.3	
St.Johann	275	12.6	14.2	18.1	21.1		62.4	12.2	12.5	28.8	26.6	29.8	38.1	14.5
St.Johann	83	14.1	15.1	16.5	18.2			11.6	11	27.6	23.9	32.2	39.8	16.1
St.Johann	210	16.6	16.1	15.8	16.3		48	12.4	11.7					
St.Johann	14													
St.Johann	94	16.2	14.5	13.7	16		63.2	13	16.2	28.1	23.2	35.7	37.8	15
St.Johann	345	16.5	16	16.6	19.5					28.3	22.5	36.4	46.4	18.2
St.Johann	9	17.4	16.6	18.6	21		62.2	12.7	12.8	26.6	25.1	31.6	39.8	16.5
St.Johann	17	14.8			17.8		59	11.3		27.4	21.8	31.8	36.8	
St.Johann	105	14.2	14.2	15.1	19.6		59.5	13.6	11.1	25.4	19.8	36.1	40.3	15
St.Johann	8	14.5	13.4	13.7	14.1			11.2	10.6	25.6	23.9	29	32.3	14.1
St.Johann	279	15.3			22.6			16.4	16.3	27.2	25	27.6	38.4	14.9
St.Johann	432	13.2	13.9	16	18.5		68.5	11.6	14.1					
"Geneva"	2	17.1	16.6	17.6	19.2	29.3		13.2	12.2	26.6	25.6	33.7	39.2	16.8
"Geneva"	18	14.9	15.2	16.2	18		69	13.2	13.5	29.6	29	30.8	39.5	18.1
"Geneva"	26	15.9	16.4	19.1	20.9			16.2	15.7	27	23.8	33.6	38.4	17.1
"Geneva"	6	13.3	14.4	16.4	18			8.6	10.6	26.2	21.8	34.8	43.2	14.9
"Geneva"	14	13.9	15.3	17.7	18.6			14	14.5	27.9	26.9		44.7	17.1
"Geneva"	3	17.3	16.9	15.9	18.7	27.8	66.4	9.8	10	25.8	25.1	34.3	43.8	16.6
"Geneva"	12	17.9	17.4	17.5	18.3			13.5	15.1	28.6	26.4	36.3	44.3	17.5
"Geneva"	1	16.9	18.9	19.9	21.2		69.4	15.3	15.7					
"Geneva"	3	16.7	16.4	16.3	18	37.9		13.6	10.5	31.6	29.6	35.5	40.2	15.2
"Geneva"	3	16.9	15.9	15.3	16.4	32.5	59.4	13.3	14.6	28.6	25.5	33.8	41.9	16.6
"Geneva"	2	15.5	16.1	16.2	17.5			12.8	11.8	28.1	25.7	34.7	42	19.3
"Geneva"	5	16.8	15.5	16.6	18.4			16.1	14.8	28.9	21.6	36.6	39.8	16.1
"Geneva"	17	14.9	14.7	16.1	18.8	29.7	63	13.5	10.9	29	25.6	35.8	43.6	17
"Geneva"	6	15.9	16.7	17.2	19.8	34.6	65.1	13	12.7	28.3	27.8	37.2	42.7	15.7
"Geneva"	8	18	17	18.8	20.8	33.2	61.2	15.1	13.2	28.3	27.1	29.5	41	15.2
"Geneva"	13	17	15.9	14.8	18.5	29.9	66	12.1	10.4	29.1	25.5	37.7	45.8	19
"Geneva"	6	16.8	18.1	16.8	16.9	26.6	68.9	13	15.2	28.8	26.9	31.6	41.2	16.2
"Geneva"	9	15.5	16.9	16.9	18.2		65.2	14.3	13.8	28.5	28	30.6	44.6	17.5
"Geneva"	13	16.6	17	15.4	18.6	26.4		13.1	15	29	25.2	32.1	38.8	15.5
"Geneva"	14	15.4	14.6	18.4	20.4	26.6	65.2	15.5	14.3	28.1			33.7	15.7
"Geneva"	4	16.3	16.8	15.9	17.1		64.6	12.7	12.6	28.6	26.9	33.3	38.5	16.5

Individual / Sample	Specimen number	L1PH/	L1M10	L1M11	L1SPL	L1TPW	L1IFicr	L1IFice	L1IFrcr	L1IFrce	LSM2	LSM1	LSM6	LSM8	LSPHI	LSPHr	LSM10	LSM11	LSSPL	LSTPW	LSIFicr	LSIFice	LSIFrcr	LSIFrce	FMM16	FMM7	HLM1	HCM7	FHM18	FLM1	FCM8	BWM2
LaFermeale	1			22.4							24.2			46.4	14.5	14.6		30.3		43.8	4.9	8.8	6.5	10.5		30.6	336					
LaChappelleauxSaints	1	14.2	17.9	17.5			5.6	6.7	7.1		24.3	26.2	35	51.7	14.2	12.5	17.6	27.7			4.9	6.9	5.5	8			309					307
CroMagnon	1	15.5	16.8	22.5			7.1	11.9	7.1	12															39.7	35.2	306	60	48.6	444	91	
AbriPetaud	6																										311	59	41.4	464	81	
Neuessing	2																										314	64	42.9	430	85	264
Veyrier	1		18.2				7.5	12.7			23.5	25.1	30	46.2	11.8	11	17.2	23.8	25.2	76	6.2	9.9	6.8	10.1			328	76	48.2	461	92	270
LaSichne	1										23.1	24.8	34.4	47.5			19.6	26.4	24.8		5.6	7.6	6.4	8.2	38.4	32.2	326	65	49.8	441	95	283
Teviec	16	16.2	13.8	20.5			5.2	10.1	5.8	8.8	25.8		32.4		11.1	11.4		24.1							42.6	34.2	306		46.9	435	95	
Granet	1	16.8	17.2	22.1	27.6			11	7.8	12.5																			42.4		77	
Veihingen	8	17.4	17.7	23.7	30.4		7.4	12.3	7.8	12		23.8	29.6	44.4	11.4					86.3	5.2							65				
Veihingen	19											20.9	24.8								5.3							60	44.3	444	80	
Veihingen	90										23.8	32	30.2	48.8																		
Veihingen	7												34.8	48.8	13.9	16.9		26.2	26.5		6	10.5					333	60	49.5	445	99	
Wanderslaben	2172	17.4	17.5	24.9	30.3		7.6	12.2	8.4	13.2		29.7	33.9	48.8	14.7						4.7							58	46.5		91	
Wanderslaben	2235	17.6							8					43.2	14.2	14.8	15.3	23.8			7.2	9.7	6.4					62	46.7		84	
Wanderslaben	2221	15.8	18.2	23			6	13.3		13	26.4			43.8	14.2	14.8	16.4	24.1	22.6	80	4.5	10.4	5.9	10.5			259	60	41.9		83	
Wanderslaben	2220	16.5	15.7	22.7	29.4		8.1	10.5	8.3	11.8	23	27.8	35.8	43.8	15.6	13.6												57	46.5		91	
Wanderslaben	2235											26.2		45.2	14.2						5							58	43.1	435	87	
Wanderslaben	2165	15.2	16.7	21.5	26.3	62.4	9.8	12.1	9.9	12.9	24.3	27.6	30.9	42.8	10.6	17.1	14.8	22.2			7.1	11	6.9	10.3			300	58	43.1	435	85	
Wanderslaben	2126	16.8	14.1	23.7	29.9		4.8	9.1		9.3	20.3	25.9	36	47.5	14.3	13.8	17.1	25.2			4.6	7.8	4.9	7.4			291	62	46.3		88	
Wanderslaben	2219	16.9	17.2	21.9	27.7		5.8	10	10.2	9.5	27.8	27.1	32.2	47.4	16.3	15.7	14.9	21.5			4.8	6.6	5.6	8.8			324	62	47.1	435	88	
Wanderslaben	2141	16.1	17	24.5	29.9		6.3	10.8	7.1	10.5	25.1	29.8	36.6	47.5	12.7	16.6	16.2	22	29	86.8	5.1	6.9	4.4	6.2			317	65	47.2		90	
Wanderslaben	2267	16.3	16.8	22	25.9	68.6	7.7	12	7.9	11.7	23	27.3	36.5	48.9	14	12.8	14.2	23.5	22.5		7.3	9.1	6.6	9.4			294	58	47.9	434	84	259
Wanderslaben	2145																												43.7	438	80	
Wanderslaben	2163	15	17.5	22.7	33.5		6.8	10.3	7.5	10.4	24.9	27.5	34	49.5	15.8	12.5	15	27.1			4.3	9	5.4	9.8			310	65	46.7	462	87	262
Wanderslaben	2264	15		24.5			7.7	11.1	7.7	11.8	25.9	29.6	32.8	54.6	16.4	12.6	17.5	28.9			4.3	8.9	4.2	7.1			329	71	46.5	458	93	
Wanderslaben	2211	16.7	18.4	23	30.2		8.4	13.3	8.4	12.6	27.2	27.5	36.1	48.3	11.8		15.1	26		54.3	6.1	6.4	6.1	9.8			308	64	47.2	441	83	
Wanderslaben	2118	16.5	16.2	24.1			7.4	12.5	7.7	13.1	24.8	29.8	32.4	48.5	18.5	19.6	18.9	29.5			5.5	11.2	5.4	10.7			302	61	45.5	424	89	
Hoeldic	9										21.2	24.5	29.8	46.3	9	8.5		23.2				14	7.1	15.7		33.9	289	62	46.2	408	77	264
Hainburg	21125	17.2	14.3	22.5		69.6	7.7	12.1	8.5	12.5	23.5	26.4	34	43.2	14.7	15.2	13.8	24.6		84	6.3	10	6.2	11	32.8	28.3	305	58	46.7	425	80	274
Hainburg	21055	15.4	20	22.6	27		9.4	13.6	8	13.2	25.6	28.5	31.9	50.4	17	16.6	17.8	28.2			4.8	12.2	5.8	12			308	66	48.2	470	90	279
Hainburg	12145	14.8	19.1	20.8			9.7	11.5	9.5			28	31.6	45.7	12.8	15.4	15	23.8				8.8		8.4	37	32.1	326	67	47.3	468	95	
Hainburg	13090	14.1	17.4	24.3	27.8		8.4	12.3	8	12.2	18.2	25.5	29.6	41.7	11.8	12.9	16	26.2	23.7	80.3	5.8	10.6	7.6	9.2				56	38.8	391	76	
Hainburg	12144																								41.5	32.5	326	70	52.6	454	95	
Hainburg	9708	16.7	17.3	23.8			8.1	12.2	8.5	11.6	25.4	29.6	31.3	47.8	15	15.5	14	28.9	34		6.2	10	6.4	10.6	36.7	30.4		64	46.8		85	
Hainburg	21097	16.1	16.1	23.2	32.8	74.9	7.2	13.5	7.6	12.6	26.5	31.6	31	43	13.5	13	19.9	24.2	30.6	45.8	6.4	10.2	6.5	9.8			298	66	47.4	432	87	270
Hainburg	9687	17.2	17.5	25	30.6	73.4	8.1	12.9	7.9	13.2	22.2	30.6	33.3	50	14.9	15.4	19	28.7	24.5	97.6	5.4	8.5	6.9	9.2	36.2	29.8	307	69	47.5	430	88	265
Hainburg	12134	16.7	16	22.6	32.7	69.8	7.9	11.9	7.2	12	23.5	29.6	32.2	50.2	13.2	13.2	16.8	29.5		95.7	4.8	11.1	5.2	10.8			307	70	48.8	456	93	273
Hainburg	13053	13.8	17.8	22.1	30.5		7.9	15.5	8.2	14.3	24.1	29.8	29.8	46.1	10.8	11.4	20	25.6	25.8		7.1	12.8	6.8	12.5	30.8	29.6	310	62	42.8	407	88	260
Hainburg	12200	14.7	16.7	21.3			7.7	11.9	8.2	12.1	25.4	27	32.6	51.4	13.8	18	16.2	22.9	25.4		6.5	8.6	7.6	8.2				67	49.2		90	296
Hainburg	21115	16.5	19.7	23.8	31.1	74.5	7.4	12.8	6.9	10.2	24.3	31.8	33.6	49.2	14.2	15.2	15	26.2	27.6	103.9	5.4	9.9	5.3	9.5			331	64	49.2	439	89	
Hainburg	13033	16.6	15.1	18.8		70.1	6.1		8.6		25	29.2	32.2	39.3		13.5	13	24.1	28.2	91		8.2	5.5	8.3	37		326		45.8	458		279
Hainburg	12143	15.2	16.8	21.9	25		7.6	11.2	7.4	11.4	21.6	25.5	32.2	48.8	13.4	13.3	15.8	25.5			6.4	10.1	8.1	9.6	34.2			43	43.3	433	81	
Hainburg	13066										22.5	27.4	30.9	44	13.8	12.6	16.1	24.1			6.5	10.2	6	11.8	34.9	29.8	305	58	44.8	448	85	
Hainburg	9723	17	17.8	26.8	25.4	71.2	9.6	13.8	9.4	12.7	24.3	27.2	34.7	52.8	14	14.7	15.7	27.2	25.3		7.6	10.2	7.1	10.3			295	53	43.1	408	78	278
Hainburg	21091	17.5	16.6	22.6			8.6	13	9.7	14.2	23.6	27.5	33.1	46.3	11.8	14.6	15.6	25.9	28.4	84.4	7.2	10.6	5.3	11.5	33.3	27	311	59	41.5	423	78	264
Hainburg	593	16	17.1	23		70.4	8.3	12.5	8.3	14	24.9	25.6	34.2	46.9	12.1	14.8	19.3	27.2			6.6	9.7	5.6	9.8				69	49.9		94	
Straubing	605	15.6		26.2							26.8	30.7	25.7	51													326	65	49.8	460	92	
Straubing	308	17.7	16.5	23.2				15.8		16.4	28.9	29.2	32.1	44.9	14.5	15.8	14.3	23.6			8.6	13.3	9	12.5			337	67	49.5		86	
Straubing	756	15.6	16.5	22.3			8.9	11	8.2	10.6	22.2	25.3	32	37.3	13	13.7	17.2	23.2		69.2	5	9.4	5.8	9.1			315	63	48	446	89	
Straubing	639	15.8	17.9	23.9	31.9		7.3	11.5	6.5	12.8	22	26.1	32.6	47.5	16.8	20	18.8	29.9			5.5	12.8	7.1	11.4			328	65			82	
Straubing	481	16.7	17.8	22.2			8.7	13.8	10.5	13.5	24.9	25.8	30.1	46.6	11.2	11.7		30.9			7.3		8.2					70	48.4	468	97	
Straubing	373	13.8	17.2	23.1	26.5		6.5	10.6	8.7	11.2	23.8			57.7	12.7	13.5	19.4	28.1	18.8		6.2	8.1	5.8	8.9				68	50.3	455	95	
Straubing	368	15.2	17.6	23.6	31.2	71	8.4	13.3	8.4	12.2	26	27.1	35.7	50.3	17.3	16.6	15.5	26.2	26	101.1	6.8	8.5	6.8	7.8			368	69	48.4	518	90	273
Straubing	275	13.2	16.2	23.8		69.6	8.1	11.8	6.8	9.6	21.6	21.9	33.7	43.6	12.5	12.1	17.7	27.1	23.6	50.8	6.4	12.3	7	11.5			332	65	45.2	441	91	
Straubing	626	17	17.4	23	32		6.5	9.8	6.6	11	24.8	25	33.9	53.8	17.1	14.6	18.6	24.2	23.9	81.8	6.2	7.8	6.2	8.4			314	69	50.2	436	90	255
Straubing	433	14.9	17.8	24	27.8		8.2	11.4	9.8	11.9	24.4	25.8	35.3	51.3	14	12.9	16.4	22.9	25.6		6.2	11.1	6.5	9.8			362	69	52.5		97	
Straubing	745	16	17.7	24.3	32.9	82.6	8	10.6	7	10	23.6	30.6	36.5	57.8	16.4	16.4	17	28.2		100.1	4.2	7	4	7.9	40.2	31		77	51.5		100	
Straubing	363	15.6	19.4	24.6			8.5	12.5	8.7	12.2	25.2	29.6	34.5	55.8	16.5	15.9		32		102.1	5.6		6.2					65	51.9	512	96	
Straubing	501	16.2	20.4	22.6	28		10.1	15.2	6.3	14.5	24.8	29.9	33.8	47	12.2	12.6	19.8	28	19.6	99.8	6.4	11.4	6.2	12.2	38	33.6	364	64	48.2	506	93	
Straubing	272	17.6	16.9	24			9.7	12	10	12.4	25.5	29.2	32.5	48.8	14.6	14.6	15.5	26.8	26		6.1	10.4	6	10.7	40.3	33.3	355	78	51.9		93	286
Straubing	636	14.8	19.4	28.6	26.1	67.2	8.5	12.5	8.9	11.9																	328	60	48.8	465	85	
Straubing	412	13.4	18.1	24.6	18.5		9.2	13	8.6	13.7	21.5	25	28.2	41.8	11.1	11.9	15.3	25.5	17.6		6.6	14	6.5	12.3				57	41.2		80	
Straubing	605	17		24.6		59.6			5.8		26.6	30.6	34.3	50.3	16	13.5											328	64	49.5	455	92	
Straubing	260	14.8		23.7			6.4		6.4		25	27.8	34.5	49.6	13.7	16.6	14.8	24.2	25.1		7	9.3	6.8	7.7			326	65	50.4	471	91	
Straubing	469	16.1	19.4	23.9	32.6		10		9.8	15.2	26.1	31.8	35	53.9	12.5	15.2		25.4					6.2					65	51.5	500	92	
Straubing	500	13.9	17.3	21.4		53	8.6	13.5	7.8	11.8	25.2	27.3	26.2	39.1	11.3	11.6	17.7	24.3	21.9	73	6.2	11	6.5	13			304	64	44.1	431	75	
Straubing	640	16.6	17.5	25.8	27.2		6.8	11.6	7.7	11.4	25	31.7	31.6	58.3	15.8	16.7											352	70				
Straubing	418	16.1	18.9	21.8			10.3	13.3	8.4	12.6	23.8	26.1		46.8	12.2	11.8	17.6	27.9			6.5	11	6.3	11	41.2	32.6	328	62	45.6	458	81	
Straubing	370	15.5	16.8	21.5	29	69.2	7.8	12.8	8.9	13.1	26.6	23.8	28.2	36.7	17.8	18.2	17.5	25.1	24.7		7.2	13.9	7.2	13.8			309	57	44.8	428	88	
Straubing	731	15.5	17.3	22.7			9.1	12.6	8.6	13.2	24.1	28.1	32.6	45.6	12.5	14.3	14.8	23.8			5.5	11.3	5.8	10.2			362	74	48.9	509	97	
Straubing	783	16.4	17.1	22.6	16.7		9.1	13.2	7.9	12.5	23.1	28.8		43.8	15	13	13.9	25.6			5	6.4	5.1	7.8		28.6	338	62	47.8	464	88	
Straubing	806	15.1	16.3	23	27.6		7.8	10.6	6.5	11	23.4	25.5	35.2	50.6	14.4	14.6	12.8	29	21.8		6.5	10.4	6.5	9.6				70	48	491	98	295
Straubing	765	15	17.4	24.7	35.3	85.6	8.3	13.5	8.6	15	24.1	28.1	32.5	50.8	12.1	14.3	16	26.9	17.8	93	6.1	10.4	5.8	12.1			364	67	49.5	505	94	
Straubing	493	14.8		24.7			9.6	14.5	9.1	14.8	26.2	31.3		42.9	16.3	17.1	18.4	30.1			8								44.6	485	85	
Straubing	438	18.3	15.3	22.1	30.6	62.4	7.1	10.9	6.6	11.1	25.4	28.7	33.3	48.6	13.2	14.9	16.1	24.2	20.6	86.1	5.7	7	5.2	6.6			312	65	49.6	425	85	
Straubing	655	14.7	16.4	23.2	26.6		8.2	11.1	8	11.8	23.2	25.2	34.1	46.7	11.8	15.1	21.1	29.4	21.5		6.9	10.8	7	10.2			355	70	46	494	99	292
Straubing	301	14.6	16	22.7	28.1	78.6	8	11.4	8.5	12.3	23.6			46.7	11.8	15.1	21.1	27.2	24.9		5.5	10.5	6.5	11			322	65	48.2	462	79	
Straubing	675	14.6	16.4	23.3	34.8	74	9.1	14.1	8.5	13.9	24.2	28.5	33.4	48.5	12.6	12.9	15.9	26.5	25.8	97.6	6.4	9.1	5.7	9.9	40.4	35.5	315	66	48.8		92	
Straubing	356	15.5	17.4	22.2		72	7.2	12.4	7.8	12	22.2	27.5	37.2	49.3	12.2	13.7	17	27	23.2	99	6.3	8.2	6.5	9.3	37.2	31.5	326	65	51.2	479	93	294
Straubing	378	15	18.5	25.6			8.2	13	8.4	13.9	22.6	24.3	39.6	48.9	11.2	13.4	15.4	27.5			6.6	8.8	6.4	8.2				62	46.8	444	85	
Straubing	296	16	21	22.9			9.4	14.9	9.2	13.8	25.9	28.1	33.5	48.6	14.9	14.9	18.5	26.4	25.5	96	6	9.9	7	9.8	35.7	31.7	333	63	48.8	464	93	
Straubing	791	14.1	16.1	22.5			8.6	11.5	8.3	11.5	22.4		25.6	44.2	12.3	11	15.8	25.2			7.3	9.6	6.2	8.8				59	48.5	376	85	
Straubing	23																										320	68				
Aesch	4	14.2	20.2	24.2			8.9	12.4	9.7	14.2															36.6	31.1	330	73	47.4	443	88	
Aesch	35	14.4	16.5	23.6			7.3	12.2	7.7	11.6																	315	60	49.4	465	87	265
Aesch	12	16.6	19.5	26.9				13.8		13.1																	361	67	51.6	494	101	317
Aesch	29										23.1	27.8	32.1	44.9	14.1	13.7		27			5.1		5.7				64		445	85	
Aesch	36										28.6	29.2	39.7	52.6	14	12					5.8						356	67	56.4	518	96	
Aesch	19	16.2	16.5	20.8			7.3		7.7		21.9	26.7	33	44.5	11.7	10.9	16	23.8			5	8.9	4.8				323	65	46.5	472	93	

Individual / Sample	Specimen number	L1PH	L1M10	L1M11	L1SPL	L1TPW	L1IFcr	L1IFca	L1IFcr	L1IFca	L5M2	L5M3	L5M5	L5M9	L5PH	L5PH	L5M10	L5M11	L5SPL	L5TPW	L5IFcr	L5IFca	L5IFcr	L5IFca	FMM15	FMM7	HLM1	HCM7	FHM18	FLM1	FCM3	BNM2
Aesch	48	19.1	20	24.4			6.6	15.8		15.3	25.9	32.2	38.6	51.1	14.4	15.7	16.8	29			5.1	9.6	5.2	8					53.2	481	104	280
Aesch	10										25	25.1	32.1	49.9	13.7	14.8	14.6	24.5		81.4	4	8.3	5	8.7				61	45.5	414	92	230
Barbing	1355	18.5	19.5	24.9		80.8	9.7	16.3	10.1	16.8	24.8	32.8	34.8	51.8	15.3	19.8	22.8	27.5		84	5.3	13.8	7.9	13.6			345	69	54.2		108	
Barbing	1358	15.2	18.2	25		78.6	8.3	14.2	8.9	14.1	27	34	37.2	49.2	18.5	18.6				67.8	5.1	9.6	5.3	8.4			365	68	54.4	498	94	280
Barbing	1280	16.5	14.6	20.4	37.6	76.9	6.8	12.7	6.4	12.9	25.5	29.6	38.4	55.8	17.7	16.9	15.5	24.5		48.7	5.2	8.4	5.2	9.9			358	70	53.6	476	84	260
Barbing	1340	17.7	16.9	24.1	35.1		7.3	10.4	7.5	10		28.2	35.7	47.3	17.1	16.1	15.5	29.1			5.2		4.9				358	70	52.6		90	
Barbing	1373	16.6	18.1	23.1		82	8.6	15	8.3	14.4	26.5	29.2	32	49.3	15.7	17.8	16.5	25.4		68.5	4.8	8.6	7.1	12.7			329	65	50.8	470	88	282
Barbing	1330	14	17.8	23.1		37.8	8.1	13.5	8.2	14.4	25.2	31.3	31.1	51		14.4													51.1	493	94	
Barbing	1326	14.9	21.5								24.9	25.5	41.8		13.9	19.8	16.9	23.8	27.3	44.8	5.6	10.2	5.6	8.9			321	64	48.1		85	
Barbing	1378	16.8					7.9		6.1		24.1	31.2	39.3	48.4	12.7		17.5	27.8			5	8.9	5	9.8			320	65	50.8	468	90	272
Barbing	1264	16.8					8.2				26.9	33.5	33.6	43.4	14.4	15.3	14.4	24.6	31.5	90.4	5.3	7	6.2	7.5			363	71	53.2		102	
Barbing	1371	14.4	17.2	24.7			8.8	14.8	9	14.4	24	26.6	36.2	50.3	13.8	16.1	19.2	29			6.3	12	6.4	11.8			323	68	50.4	475	88	
Barbing	1266	15.5	18.5	26.6			10.4	14.4	9.7	14.4	23.8	28.6	35.4	54.5	18.6						5.3	10.6					328	70	49.9	462	90	
Barbing	1395	14.5	16.7	23.8		89.8	8.3	11	8	12.4	27.2	27.9	37.6	44.1	14.8	18.6	12.8	27.8		47	5.2	7.4	4.7	8			348	67	48.2	486	92	295
Barbing	1288	14.1	16.8	21.6			6.2	10.5	6.3	10.5	21.2	25	31.8	42.5	12.6	13.1	16	21.1	25.5	48.2	5.3	9.5	5.8	10.5			294	65	44.1	411	80	
Barbing	1277	14.5		24.4							25.5	29.8	35.8	43.7	14.6	14.5	14.8	22.3			5	6	5.2	6.4				62	47.5	450	90	
Barbing	1269	17.5	18.7	26.2	28.5		7.7	13.2	7.2	12.7	25.1	28.6	39.5	50.1	14.9	16.5	16.2	29.7			5.4	10.8	5.8	11.1			333	65	51.2	479	88	280
Winterthur	6	16.9	18.5	25			8.8	14.3	8.9	13.3		25.8	35.2	46.8	14.3	16.1					6.3	8.5	6.5	10.5			332	69	47.9	478	98	
Winterthur	141	17.2	17.4	23.4		74.4	10.2	11.8	10	13.5	25.7	27.9	34.4	45.6	14.8	17.6	12.4	23.2		89.4	5	8.5	5.3	8.4			350	65	47.5	463	90	
Chur	66	18.2	17.8	23.1			6.6		8.4		29.2	32.8	36.6	52.1	16.4	16.3		25.8			5		4.7				338	70		473	95	
Chur	46	15.2	16	25.8	28.3	72	7.6	10.8	8.1	10.2	22.7	26.6	33.3	48.4	13.1	12.8	14.4	26.2	27.2	96.8	5.1	8	4.3	8.5	35.9	38.8	312	61	42.4	415	82	280
Chur	63																										340	65				
Chur	40																										325	60				
Chur	533	16.7		27.1		88.9																										
Chur	30																								34.8	33.8	304	60				
Chur	408	14.2	17.3	23.7		81.7	7.9	11.9	8	11.8																			52.6			
Chur	31										24.1	28.6	34.6		14.1						5.3								52.8	477	93	
Winterthur	84	14.6	17.6	24.2		71.8	9.2	13.3	8.1	11.6	28.3	33.8	35.5	46.4	13.9	15.4	15.4	27.1			5.2		4.4	8.5			331	68	44.7	442	96	295
Winterthur	24	14.8	17.8	22.9		71.6	6.8	12.9	8.2	11.7																		67	48.1		80	
Winterthur	80										22.3	29		44.4		11.8											336	66	48	458	84	
Winterthur	51	16.7	17	23.9	33		7.3	9.8	7.5	10.8	21.5	28.7	36.3	53.6	13.8	14.1	17.5	26			7.3	10.3	6.2	10.2	39.3		320	70	50.5	441	96	288
Winterthur	79	16.3	18.1	25.6	35.7	66	7.4	11.8	8.8	12.3	26.3	30.4	30.8	45.7	13.3	14.4	17.8	26.8	31.5	69.2	5.8	10.6	6.3	10.8	35.9	30.9	332	65	52.9	468	90	278
Winterthur	80	16.5	16.4	21.9			6.4	11.2	7.8	11.8		31.4	26.6	46.7			14.6	25.5			5		6				316	60	43.9	446	96	280
Winterthur	72						7.6				24.2	31	32.9	47		14.8											353	71	49.1		93	
Winterthur	76																								32.2	27.9			44.8	455	82	
Winterthur	86	16.9	18.2	26			8.2	12.8	8.2	11.8	30.4				12.9	13.3												71	50.8	452	95	268
Winterthur	75	15.8	20.5	24.8	32.4	73.6	8.3	14.9	8.4	14.2	25.3	28.3	35.8	51.7	13.6	11.2	20.5	27.3	24.5		5.6	11.2	5.1	10.1			344	66				300
Winterthur	14																										325	57				
Winterthur	17										21.9	27.9	31.7	50.8	14.2	14.2	18.8	27.6	25.3		4.8	9.7	5	9.2	35.3	30.9	330	65	49	458	100	283
Winterthur	94	14.6	17.2	23.4	29.4		8.7	13.1	7.1	12.2	23.3	29.9	32.4	43.4	13.6	13	17.3	25.1	25.7	84.1	5.6	10.1	6.2	10			331	65	46.8	455	89	286
Winterthur	82	17	16.8	22.3			9.1	11.8	8.9	10.6	29.6	31.6	39.5	50.2	13.9	14.8	15.4	25.5	33.2	96	5.6	7.5	6.3	7.8			365	73	55	522	105	310
Winterthur	30	17.9	17.9	23.6			8.3	13.2	8.4	11.8	29.6			46.6	15.9	15.7	15.8	27.2			5.9	11.2	7.2	9.8	39.3	30.9		68	48	466	95	
Winterthur	96	17	20.2	25.5			7.5	13.2	8.4																35.7	33.5		64	48.2	464	97	
Winterthur	83	15.5	18.5	26.8			8.4	13.5	9.5	14.3	21.8	30.3	30.8	44.6	14.7	15.2	15.8	26.8	31.8		5.8	12.1	6.7	11.4	34.7	31.5	311	64	46.9	460	77	
Winterthur	18																											67			91	
Winterthur	5	15.1	18.7	24.9				12.6		12.1	25.4	31.8	31.5	43.3	15.8	16.5	19.5	31.5				9.8	7.1	9.6				62	51.8	448	86	
Winterthur	7	14.9	18.8	24.5			8.2	12.8	8.2	10.8	24.9	30.5	31.8	44	14.2	13.9	19.2					14.2	5.8	10.3	37.2		324	66	48	433	89	
Winterthur	116	15.4					7.8				25.5	31.5	32.2	40.8	11.6	13.8	19.8	25	27.7	87	4.8	10.8	4.7	10.4			325	58	43.3	444	92	274
St.Johann	216	14.8	16.8	23.6		72.2	8.6	12.8	7.7	13.9	24.5	29	32.5	46	14.2	14.8	19.2	25	28.8	94.8	6.3	9.7	5.7	10.4	39.4	36.2	337	69	47.8	469	93	300
St.Johann	107	17.1	18.5	25	41.5	87.6	9.3	16.5	9.7	15.2	24.9	26.8	39	53.3	14.7	13.3	16.2	29.4		85.2	6.3	8.2	6.1	9.8	39.8	28.9	346	77	51	473	77	
St.Johann	724	17.5	18	24.6			10.7	17.4	10.4	16.8	24.2	32.9	38.6	57.2	17.3	17.7	19	28.2			7.3	7.1	7.8	8		28.8	350	73	56.2	470	102	
St.Johann	90	15.8	15.8	22.8			7.9	8.3	6.3	10.9	22.6	29.1	35.1	44.1	12.5	12.8	17.4	27.5		86.2	5.4	10.4	5.3	8.8	36.4	30.4	326	65	49.1	448	86	308
St.Johann	597	13.8	17.8	24.2			8	11.5	8.1	11.4	21.2	30.6	33.2	43.6	10.8	13.6	16.2	25.4			5.3	8.2	5.3	7.8	37.4	32.6	297	58				
St.Johann	293	17.1	15.2	21.9			7.4	11.5	7.3	12.3	21.7	28.7	35.4	52.8	15.1	16.8	17.5	23.6		83.8	5.3	8.8	5.5	7.7	33.3	30	338	66	48.8	475	84	280
St.Johann	426	16.1	19	26.2		80.2	8.8	14.3	8.4	8.3	25.9	33	34	54.5	12.9	12.2	19.2	24.2	30.6	99.5	6.1	8.4	6.4	8.3	40.9	33.5	344	69	48.5	460	88	
St.Johann	349	12					5.3				25.6	25.3	28.2	39.5	13.2	12.7	14.5	20.2			7		5.4	9.6			286	62	40.8	391	81	
St.Johann	275	15.5	21	28.5		76.6	9.9	15.2	8.8	15.9	21.1	28.2	33.3	47.8	11.8	10.9	21.2	28.4	32.2	88.6	6.8	12.5	7.6	11.3	40.1	34	331	60	47.4	468	82	297
St.Johann	93	16.6	18.3	21.9			7.4	8.9		11.1	22.1	30.2	35.5	46.2	11.9	13.9	18.8	22.9			5.4	5.5	5.4	7			325	68	48.8	454	84	287
St.Johann	210																								30.6	32.2		65	47.2	436	93	
St.Johann	14										22.6	31.6	31.2	45.6	13.7	14.5	16.5	21.2		80.6	4.5	9	4.7	6.8			303	65	48.2	444	88	275
St.Johann	94	15.2	15.8	22.2			7.5	10.2	7.7	11.1	25.1	28.7	32.6	42.9	13.5	13.2	15	25.2			5.5	10.5	5.8	10.6	33.4	28.6	316	61	49.1	449	91	
St.Johann	345	17.8	18.2	27.1			8.3	15.2	8.5	11.1	26.8	32.5	34.8	54.7	13.2	14.5	20.6	29.2		104	6.5	10	6	11.3					55.7	514	97	305
St.Johann	9	16.4		27.3			10.2				22.9	29.8	34.9		15.2		18.7	26.9		88.6	6.1	10.3		11.2	40.3	34.2		67	50.9	466	94	275
St.Johann	17	15		26.4							22.6	27.6	29.1	43.9											35.6	33	316	68	47.5		85	
St.Johann	105	14.8	15.1	24.7		82.2	7.6	11.6	7.1	10.6	21.9	27.6	32.1	43.2	12.8	13.8		23.2		78.8	6.2	6.8	7.1				320	68	48.3	447	88	290
St.Johann	9		14.5	20				11.3		10.2		20.5		38.8	13.3	12.9	16.9	23.2		78.8	5.1	9.1	5.1	10.2			319	57	46.2		72	256
St.Johann	278	12.9	21.8				11.2	16.8	9.8	15.6	20.1	27.8	28.2	41.3	10.4	12.2	17	32.7			6.3	12.6		12.3	38.8	35.5	329	56	49	425		
St.Johann	432											26	30.4	43.6	12	11.2	22.2	23.5		84.3	5.9	7.8	5.2	8.8	33.3	29.4	325	69	49.1	468	92	290
"Geneva"	2	16.5	19.9	27.2			9.7	14.1	8.7	15.4	23.8	28.1	35	47.6	15	15.1		29.7		92.8	6.4	14.7	6.5	10.2	40.6	34.5	340	71	52	456	97	300
"Geneva"	18	19.7	19	21.9		70	9.2	12.4	11.4	13	27.4	29.8	34.6	52.9	14.9	16.3	18.3	25.3			8.9	8.8	7.4	10.7	38.5	32.9		66			98	275
"Geneva"	26	18.1	18.3	26.2				15.2	8.3	15.1	21.1	25.6			12.2	13.4	21.7	29.4	27.8	79.8	7	13.3	6.5	12.6			297	65	49.1	418	87	
"Geneva"	6	18.4	18.2	24			8.7	13.2	9.4	14.8		26.6		54.6	13.2	13.6	14.4					10.6		7.5	38.1			76	51.5	434	88	
"Geneva"	14	17.8	18.7	23.2			8.6	13.5	11.2	11.5	25.6	28.7	41.2	52.2	13.8	16.9	14.1	22.1	34.3		7.8	8.5	6.1	8.5	36.5	29.7	318	75	55.5	443	96	320
"Geneva"	3	17.1	15.9	23.5	34.8	84.4	7.2	10.6	8	10.4		29.7		47.2			15.2	26.8			7.7		5.8				310	65	47.3	409	80	260
"Geneva"	12	17.5	18.3	26.2			8.4	14.8	8.4	15.8	25.4			51.6	14.1	14.8	18	30.6			6.2	10.5		11.2	38	30.6	336	72	53.2	442	91	275
"Geneva"	1										24.3	30.5	34.3	51.2	15	15.3		31.5	32		8.5	14.8	8.4				332	74	49.5	409	95	306
"Geneva"	3	17.8	16.1	22.4			7.3	10.2	8.3	11.6	27.8	30.6	34.9	48	15	14.7	12.5	21.1			5.8	7.7	6	6.9	35.2	35.7	332	71	48.7	429	94	322
"Geneva"	9	16.2	19.3	23.2		80.4	8.4	15.2	8.6	13.9	24.8	26.9	35.8	51.8	14.9	15.1	19.4	26.5		98.4	7.1	10.4	7.2	9.8			338	66	48.2	474	93	
"Geneva"	2	19.6	18	23.5			7.1	12.5	9.9	13.4	25.8	28.2	35.9	48.9	16.5	15.9	17.8	23.2	36.3		7.1	12.7	6.8	13			328	68	50.1	462	88	280
"Geneva"	5	16.1	17.6	26.1			8.5	14.6	9.8	12.8	25.3	25.6		51.1	14	15.4	16.8	29.5			7.3	7.9	6.7	6.7	38.1	34.2	321	67	41.4		87	
"Geneva"	17	16.4	18.9	25.8	32.2		8.9	13.2	10.6	13.8	25.2	28.6		52.8	13.4	16.1	18.2	29.4	24.6	95.5	7.9	9.2	7.2	9.6	38.6	32.1	323	68	52.6	456	93	
"Geneva"	6	16.2	18.2	25.8	38.2	79	7.8	8	8.6	12.9	22.2	28.1	37.9	49.7	13.8	17.7	20.5	29.3	26	97	6.4	10.7	6.5	11.1	40.1	35.3	340	70	49.4	450	109	298
"Geneva"	8	16.8	18.3	24.6		78.3	8.9	12	9.3	12.1	22.9	28.5	35.8	53.2	16.4	14.3	17.7	27.9	31.9		6.8	11.7	6.4	11.3	35.8	33.9	335	68	51.5	469	88	295
"Geneva"	13	18.6	16.7	23.7	30.5	66	7.7	12	8	12.4	26.6	30.3	41.2	46.8	13.8	14.1	16.1	23.8		97.8	6	8.5	5.7	8	37.7	32.6	323	76	53.1	473	101	290
"Geneva"	6	16.8	19.8	24.3	22.1	74.8	8.9	14.4	9.3	13.4	23.8	30.4	33.2	46.8	18.3	18.8	21.8	28.5			7.8	11.5	8.3	10.8	34.4	28.7	347	75	50.5	485	96	286
"Geneva"	9	17	19.7	21.8		76.6	7.7	14.1	7.8	13.8	25.2	28.4	35.7	52.9	14.1	14	17.7	25.6			5.3	14.5	5.2	10.9	38.2	33.7	326	70	51.5	457	91	
"Geneva"	13	16.1	18.8	23.8	27	78	7.6	12.6	8.6	12.8	25.9	30.1	36.9	43.6	13.8	14.8	17	26.8	24.6	85.1	5.4	8.7	6	9.5	36.5	33.2	325	65	48.3	447	84	275
"Geneva"	14	15.3	19.5	24.8	32	71.4	11.8	16	11.2	15.2	23.8		33.2	43.4	14.1	13.8	17.2	27.1			8.1	11.5	7.6	10.8	38.5	30.5	316	66	46.3	453	80	
"Geneva"	4	16	18.8	22.7		72.4	9.2	12.7	8.1	13.1	24.3			48.5	14.9	16.2		28.2			7	12.1	7.3	11.6			320	57	47.5	441	78	

Females Individual / Sample	Specimen number	BP	agegroup	C2M2	C2M1	C2M6	C2M9	C2PHI	C2PHV	C2M10	C2M11	C2SPL	C2TPW	C2Flcr	C2Flca	C2Frcr	C2Frca	C7M2	C7M1	C7M6	C7M9	C7PHI	C7PHV	C7M10	C7M11	C7SPL	C7TPW	C7Flcr	C7Flca	C7Frcr	C7Frca	T1M2	T1M1	T1M6	T1M9	T1PHI	T1TPW	T1M10
CroMagnon	2	25000	1															13.5	12.8	13.9	23.5	5.7					5.6	8										
Teviec	1	8000	1	12.2	11	15.3	17.5	6.8	7.7	14.3	22.5	13.6	52.4	5.5	7.2	4.9	7.7	13.6	13.6	15.5	22.2		7.3						5.4	9.3	15.3	14.8	15.1	28.6	10.1	11.6	15.1
Valhingen	115	7200	2															13.1	13.4	16	25.6	5.4	5.9	14.1	24.7			5.5	10.3	6.7	8.1	13.5	14.7	15.5				
Valhingen	53	7200	1	12.4	13.5	15.6	17.4	5.5			22.2			5.8	6.6			12.8	12.9	15.2	24.8	7.8		14				5.8	9.3	5.2	8.4	14.5	13.9	15.7	24.6	7.8		14
Valhingen	45	7200	1												3.6																						
Valhingen	87	7200	1	10.3	10.6	15.3	17.4																															
Valhingen	14	7200	1	13.2	12.4	15.5	17.3																															
Wanderaleben	2241	7000	3	13.7	14.3	17.3			6.9							5.4	8																					
Wanderaleben	2124	7000	1	12	12.9	14.3	17.3	6.8	5.8		22.5		46.9	5.7	7.2	7.2	6.6	14.3	13.2	15.3	24.8	6.8	6.4	14.5	22.9	24	36.6	5.6	8.5	6.4	8.7	16.5	14.5	14.4	23.8	8.7	8.8	15.6
Wanderaleben	2298	7000	2	12.2	13.3	16.4	15.8	6.8	8.2	14.3	20.3	13	47.6	4.2	7	3.3	5.4	13.5	13.4	16.3	25.5	7.2	7.8	13.9	23		38.1	5.4	9	5.6	8.8	15.6	15.2	16.8	25.8	10.7	10.2	13.9
Wanderaleben	2243	7000	2	11.7	10.8	15.5	13.3	7.2	5.6	14.2	20.8		46.2	5.3	6.3	5.7	5.8															13.6	13.9	17.5	26.2	8.6	8.4	15.2
Wanderaleben	2230	7000	1	12	12.8	14.3	19		5.9		22.4		48.8			6.2	7.4	13.3	12.8	14.3	23.5											15.9	14.9	14.5	23.4	7	6.8	14.4
Wanderaleben	2214	7000	2	10.2	11.8	15.6	21.2	7.2	6.3	13.1	22.6		53.2	3.6	3.8	5	5.6																				
Wanderaleben	2250	7000	1	10.3	10.2	14.7	17.6	5.5	5.8		21.4			5.9	7.3	6.6	6.5	11.5	11.5	15	25.2	5.4	5.4	14.8	24.1		47.1	7.2	8.9	7.3	10	13.4	13.7	15.7	23.3	7	6.5	14.2
Wanderaleben	2200	7000	3	12.2	12.6	16.8		5.4	7.5		21.5			4	5.2	3.4	4.3		12.6			6.8	7.3		22.7		43.7	5.3		6.1	7.8							
Wanderaleben	2207	7000	2	12.6	12.6	15.3	23	6	5.7	14	21.5			4.5	6.1	5.6	7.3																				
Wanderaleben	2146	7000	1								22.2																										
Wanderaleben	2295	7000	1	11.9	12.9	14	16.7	4.9	5.8	15	21		44.2	5.8	7.3	5.2	6.2	13	12.9	14.4	25.3	5.6	5.3	14.3	23.7			5.6	8.7	5	7.4	15.2	14.5	15.6	24	7.6	7.2	14.1
Wanderaleben	2300	7000	2																																			
Wanderaleben	2253	7000	1	12.2	12.4	14.4	20.8	6.3	6.5	14.7	22.7		46.1	5	7.5	5.2	6.3	12.1	12.8	15	19.6	6.3	6.5	14.8	22.6		46.2	6.4	6.5	5.5	7.5				27	9.6	9.5	14.2
Wanderaleben	2294	7000	1	11.8		15.2	24	6	6	14.5	21.8	9.4	50.4	4.8	4.7	3.8	4.3	13.6	12.5	15.2	27.1	7.5	7.4	13.6	23.7	29		5.5	8.9	4.5	9.5	15.1			28.2	7.6	8	12.9
Wanderaleben	2253	7000	2	12.2	10.7		19.5	8.3	7.4	12.1	21.4			3.9	7.6	3.8	5.6	13.6	13.2	13.6	27.7	6.5	6.7	12.2	22.8	29.6		5.1	5.8	5.8	6.7	16.4	15	13.8				
Wanderaleben	2137	7000	1																																			
Wanderaleben	2195	7000	3															12.3	11.4	15.8	23.5	6	6.5	14.1	24.5		48.2	4.4	6.1	5.3	6.5							
Wanderaleben	2155	7000	2	12.2	12.8	15	19.5	6.5	5.8		22.5		52	5.2	6.8	5	7.7	13.3	12.4	17	26.1	6.5	5.8	15.1	24.4			5.8	10.9	7.1	10.4	15.1	14.5	16.5	28.9	7.7	7.6	15.1
Wanderaleben	2174	7000	1	12	11.9	15.3	17.9	5.7	5.2	14.1	21.5	11.4	48.8	5.7	6	6.3	6.5	12.8	11.5	13.2	24.5		6.5							5.5		14.5	13.9	16.3	23.2	8.5		
Wanderaleben	2112	7000	1	12.8	13.3	14.5	18.5	6.3	5.9	14.1	21	13.4	46.4	4.4	8.5	6	7.5	14	13.3	14.2	24.3	7.3	6.6	15	23.2	28.8	46.5	6.1	8.4	6.1	9.2	16.2	15.1	14.3	26.5	7.8	8.2	15
Wanderaleben	2225	7000	1	11.4	10.8	14.8	20.8	5.9	6.1	15.6	22.6	11.2	50.4	5.1	5.8	4.1	7.2	11.5	12.5	15.1	24	6.3	6.3	14.4								14.2	14	15.5	25.8	7.9	7.5	14.4
Wanderaleben	2189	7000	2	13	13.5	16.9	21.9	5.8	6.4				52.1	3.6	4.7	4.3	3.9	14.9	14	15.6	27.2	7.3	5.1	13.5	24.5			5.9	9.1	6	8.7	17.2	15.4	15.8	25.3	8.4	8.7	14.8
Wanderaleben	2187	7000	1	12.8	10.1	13.1	15.1	8.2	6.6	15.2	24.4	11.2	48.8	5.1		6.2	7.4	13.4	13.7	16.1	27.9	7.3	5.3	15.2	25.5	23.8	46.1	5.9	9.7	6.8	9.8	15.7	14.1	16.6	26.5	7.4	8	15.6
Wanderaleben	2234	7000	1																																			
Wanderaleben	2114	7000	2	12.2	12.5	16.6	22.1	6.8	7.4		23.6	14	48.5	5.9	7.5	5.1	8.5	13.9	13.8	16.2	25.6	6.8	6.7	14.9	22.5	30.5	43.4	6.4	9.6	6.2	10.1			17.3	26.2	8.7	8.5	15.1
Wanderaleben	2229	7000	2	10.9	10.4	14.3	19.8	7	6.8	15.8	19.2			4.4	4.4	3.8	4.8	11.6	10.8	14.7	25.3	6.5	6.6	12.9	22.3			4.7	6.7	5	7.5					8.2	9.6	
Hoeldio	6	6600	1															14	14	16.4	26.5	6.1	6.4	13.2	20.6			5.8	7.3	5.1	8.8	14.8	12.9	17.5	21.1	9.6	9.2	13
Birsmatten	1	6300	2																																			
Hainburg	21126	3600	2																																			
Hainburg	21059	3600	1															14.1	13.2	13.5	25.3	8.8	5.8	14.3	21.8	25.2		5.1	8.6	5.7	10							
Hainburg	21078	3600	1	12.5	12.6	14.2	17.8	6.2	6.2	13.6	21.6	13		6.1	6.8	6.5	8.5	14	14	13.6	21.8	5.4	5.4	14.5	24	27.8		6.8	9	6.8	9.5							
Hainburg	21066	3600	1	11	11.8	15.1	17.2	5.6	6.2	14.2	23			6.6	8	7.8	9.1	14.1	14	15.2	26.1	6.6	5.7	13.9	23.3	28.9		6.4	8.8	6.6	10	15.2	13.6	15.6	26.2	9.3	8.8	14.7
Hainburg	21116	3600	1	12.8	13.2	14.6	17.6	6.4	5.4	15.2	23	12.8		6.2	8.2	9.4	10.2	14.4	14.2	14.6	23.5	7.7	7.2	15.3	23.3	28.1		6.5	10.7	7	10.6	16.3	15.8	15.4	27.2	8.8	10.2	16.1
Hainburg	13055	3600	1																																			
Hainburg	9715	3600	1	12.1	10	13.2	20.2	5.1	5.3	15.4	23.2	16.6	49	8.1	9.3	6.5	8.6																			
Hainburg	13036	3600	1	12.1	11.7	13.8	20.6	5.8	5.1	14.4	23.2			7.3	8.4	7.5	8.9	13.2	10.6	14.1	24.5	5.1	4.9	14.9	25.5			7.4	10	7.8	9.2	15.3	12.4	14.8	29.5	5.5	5.8	15.4
Hainburg	21051	3600	1	12.1	11.6	14.6	20.3	5.8	5.5	15.6	22.9	11.1		6.4	8.2	8.5	9.5	12.9	11.9	15.5	23.9	5.3	5.1	14.9	22.2	30.6		7.8	10.7	7.9	10.8	15.6	13.1	17.2	26.4	7.5	7.8	14.4
Hainburg	9661	3600	1	14.2		13.8	20.2	7		15.2	20.6	14.2		6.3	8.5	5.3	9.4	14.8	14.1	14.8	23.9	5.8	6.5	14.3	22.9	27.8		6.4	9	6.4	9.3	16.4	16.5	12.8	24.7	8.6	8	14.8
Hainburg	21090	3600	1																																			
Hainburg	9885	3600	1															13.3	13	14.3	26.2	5.8	5.6	13.9	22.8	28.1		6	9.8	6.2	10	15.1	14	14.5	27	9.2	9	14.8
Hainburg	9730	3600	1	12.2	11.8	14.9	20.3	5.8	5.8	16.2	23.9			7.2	9.5	7.5	9.4	14.5	14.2	17.1	26.6	7	7	13	21.3	28.7		8.3	10.4	7.5		17.1	13.2	15.2	26.5		9.8	14.3
Hainburg	12133	3600	3															12.9	12.3	15	23.6	6	5.8	14.6	22.3	25.8		6.5	9.8	5.8	9.2	15.3	14.8	15.8	29.2	7.9	7.3	14.2
Hainburg	13117	3600	1	12.5	13.5	16.3	18.3	5.5	5.8	15.6	23.8	11		7.8	7.9	6.5	8.1	15.2	15.1	17	25.3	6.3	6.8	14.7	25.5	28.2		5.8	9.5	7.3	9.4	17.8	17.4	16	29.4	8.9	9	15.3
Hainburg	13083	3600	2															12	12.6	17.2	24	7.6	8.8	11.4	20.3	15.9		5.5	9	5.6	8.3							
Hainburg	9729	3600	1	12.1	12.6	12.7	17.9	4.8	4.8	14.7	23.5		47.2	6.6	6.8	8.7	9.4															16.9			8.2	8.8	14.2
Hainburg	12139	3600	1	11.5	11.8	12.5	14.9	4.2	5.1		21.1			5.7	6.9	6.5	7.1	11.8	11.6	12.6	21.5	4.8	5.3	13.6	22.9	26.8		6.8	9.6	6.7	9.1	13.3	13.6	13.1	23.7	5.9	6.9	14.7
Hainburg	12137	3600	1															13			30.8			11.4	18.3	37.1	34.3	6.2		6.4		13.3			29.7	10.1	7.9	12.4
Hainburg	9707	3800	1	12.2	11.8	14.2	22.9	6.6	6.6	15.4	23.3			6.5	8.2	6.7	8.3																			
Hainburg	21111	3800	1	13.2	13.2	14.2	18.6		5.5	13.2	23.1				5.3	6.2	6.2	13.9	13.8	13.6	23.3	5.5	5.3	13.1	23.5			6.4	8.4	5.8	8.5	16	15.8	13.8	27	8.7	10.5	12.5
Hainburg	21085	3800	1	14.4	13.5	16.5	25.2	7.5	6.8	13.5	22.3	14.7		5.6	7.3	6.6	6.3	14.3	13.7	15.7	29.2	8.7	8.2	12.9	21.9	21.7		6.1	10.2	5.8	9.5	16.1	15.7	16.9	29.2	9.8	9.1	13.5
Hainburg	21067	3800	1	11.6	11.4	13.4	21	5.5	5.2	16.6	24.1			8.5	10.4	8.4	10.3																			
Straubing	631	1400	2	12.7	12.8	14.2	19.6	6.2	5.9		24.3		49.6	5.7	5.2	6.1	6.4	14.3	13.2	14.8	24.5	6.5	6.7	15.9	25.5			5.8	11.3	6.5	9.8	16.1	15	15.5	26	8.6	8.9	16.3
Straubing	780	1400	1	12.6	10.2		21.1	6.2	6.5	15.6	23.8			7.6	8.5	5.8	8.8																			
Straubing	415	1400	1	13.4	12.8	13.2	20.1	6.3	6.2		23.2			6.2	8.8	6.7	8.9	13.9	13.2	15	22.1	5.4	6.5	14.6	24.6			5.8		6.7	10.8	14.8	14.5	15.2	25.1	8.4	7.8	14.5
Straubing	286	1400	2	10.6	9.2	13	17.8	4.3	6.3	16.6	26	13.3	46.8	5.2	5.2	6.5	9	12.5	12.1	13.8	24	6.2	5.6	18.1	29.5	24		5.8	12.1	7.2	9.8	14.6	13	13.5	27	8	6.3	18.5
Straubing	741	1400	2	13.5	12.2	15.1	19	6.1	6	14.2	23.9			7.2	7.3	7.9	8.8	13.8	13.2	15.7	24.6	6.5	6.6	14.5	23.6	24		6.8	10.1	6.5	10.5	14.8	13.3	16.8	31.9	8.1	7.6	14.5
Straubing	734	1400	3	13.4	12.6	17.3	18.1	6.7	5.7	14.6	23.9	14.8		7.3	10.2	7.6	10.4	13.6	12.1	16	29	6.5	6.4	14.6	25			5.6	10.1	6.1	10.2	19.3	12.1	16.3	27.2	6.8	7.8	15.8
Straubing	394	1400	1	13	14.6	14.7	17.5	5.5	6	13.5	22.8	12.8	45.3	6.1	6.2	6	7.6	14.6	14.2	15.6	23.4	7.2	7	13.6	24.2	29		7.1	11	6.3	10.1	15.8	14.9	15.8	28.8	7.6	8.6	
Straubing	725	1400	3	11.8	11.1		21.5	5.8	6.3		24.5			7.9	6.4	7.8	7.3																			
Straubing	810	1400	1	12.3	11.5	13.4	21.8	5.9	5.5	15	25.1			7.2	10.9	6.8	9.8	12.1			32	5.6	6.1	15.6	26.2			8.8	11.8	6.3	11.5	14.4	14.2	14.8	28.9	8.6	7.6	16.1
Straubing	744	1400	1	12.2	11.9	14.2	18.8	6.4	5.8		24.2			6.8	9.4	6.4	9.8	13.1	12.8	13.1	24.5	4.2	4.9	15.8	26			6.6	10.9	7.5	11	15.5	14.2	13.9	28.2	8.2	6	15.8
Straubing	462	1400	2	12.8	12.6	13.8	15.8	6.4	6.9	12.5	23			6.9	9.5	5.2	7.3	14	11.8	16.4	25.4	6.3	7.9	13	25.5			6	8.8	6.7	9.3	14.9	14.3	15.9	28.5	7.6	8.1	14.2
Straubing	351	1400	1	12.4	13	16.2	19	5.2	5.3	14.9	23.3	14		5.1	6.8	4.5	7		11	16.6	27.8		6.3	14	27.1	25.2			10.4	7.3	11.4	15.4	14.5	16.5	27.4	7.1	7.6	14.3
Straubing	474	1400	1	11.9	11.2	16.1	18.7	5.6	5.6	15.1	23.6	10.6	52.6	7.9	7.1	7.3	9.4	12.5	11.5	15.8	26.6	6.3	6.6	14.4	23.8	30.2		6.5	9.4	6.1	9							
Straubing	614	1400	1	12.9	12.3	16.2	16.5	5.4	5.9	13	23.3	10.1	49.5	8.7	8.7	6.8	6.6	12.9	12.4	17	22.5	6.9	6.8	12.6	24.5	27		6.1	8.7		8.5	16.3	14.2	15.2	26.1	10.1	7.6	15.6
Straubing	811	1400	2	14.5	13.5	15.8	19.1	8.1	6.6	15.1	22.3			7.5	7.4	6.7	7.8	15.2	14.3	15.8	24.3	9.1	8	17.2	23.6	22.6		5.1	10.9	7.5	11	17.8	16.5	16.4	26.9	10.7	10.1	16.6
Straubing	624	1400	1	12.8	13.4	12.1	19.9	6.8	6.1	16.5	23	15.2	48.4	6.9	8.5	6.9	10.1	13.9	13.4	14.5	24.3	7	6.8	14.8	25.4	29.1	69.2	6.8	9.4	7.4	9.5	16.2	15.1	15.9	23.8	8.2	9	14.8
Straubing	305	1400	2	11.5	10.9	15.3	16.6	5.2	5.3	13.6	24.3	12.2	49.1	7	8.7	6.8	8.8	13	13	16.9	24	7.4	6.3	14.4	25.2	25.6	61.9	8.3	11.4	7.8	10.3	14.4	13.6	15.4	27.8	9.4	8.3	
Straubing	279	1400	1	12.2	12.1	14	19	4.8	5.4		22.7			6.5	8.3	6.3	8.3															14.1	12.9	16.5	21.4	6.9	7.3	13.6
Straubing	792	1400	1	10.6	11.8	13	16	4.4	4.8	14.6	23.3			7.3	6.6	6.8	8.6															15.3	14.5	12.6	27.5	7.6	8.1	15.3
Straubing	468	1400	1	13.2	11.8	13.7	16.6	5.4	5.6	14.2	23.9		47.8	8.2	6.1	7.8	8.7	13.9	11.8	14.6	22.2	6.2	5.8	14.5	24.1			15	12.8			15	15	16.8	22	8.4	7.8	14.2
Straubing	481	1400	1															12.5	12	16.8	24.6	6.8	5.8	13	24.8	21.6		5.4	8.5	5.8	9	15.4	15	16.8	29.1	7.8	8	13.6
Straubing	501	1400	3	12.5	12.9	15.9	17.7	6.8	6.8		22		49.7	6.8	6	7.2	9.5	13	12.3	17.1	23.6	7.7	6.5	13.2	23.2			6.5	10.2	6.1	9.2	14.5	13.4	18.5	24.1	9.1	9.2	13.2
Straubing	766	1400	1															13	12	13.9	24.9	7.4	6.8	12.3	22.9	22		5.9	9.4	6.1	9.2	14.8	14.9	15	26.1	8.8	9.8	13.1
Straubing	795	1400	1	15	11.5	15.2	21	6.6	7.4	14.9	25.8		62	7.6	10.7	9.2	10.4	16.6	15.3	15.8		7.1	7.6		22.2							19	16.2	16.3	31.2	10.1	10.2	13.9
Straubing	377	1400	2	13	11.8	18	18.5	5.4	5.2	13.8	23.4			7.3	5.1	6.8	6.6															16.3	15.4	15.5	25.1	8.7	8.2	13.8
Straubing	248	1400	1	12.4	12.8	14	18	4.9	4.9	16.2	25.2			8.6	10.4	8.2	10.2	14	13.1	14.3	22.2	6.8	6.9	16.2	24.6			8.6	11.8	8.8	11	15.9	14.8	15	23.9	8.6	9.2	17.6
Straubing	484	1400	1															14.9	14.2	16.8	23.5	6.9	7.2	13	22.1	20.7	58.4	5.9	9.3	6.2	10.5	16.5	15.5	17.1	26.4	8.9	9.5	14
Straubing	425	1400	1																																			

Individual / Sample	Specimen number	BP	age group	C2M2	C2M1	C2M6	C2M9	C2PH9	C2PHv	C2M10	C2M11	C2SPL	C2TPW	C2IFcr	C2IFce	C2IFcr	C2IFcra	C3M2	C3M1	C3M6	C3M9	C3PH	C3PHv	C3M10	C3M11	C3SPL	C3TPW	C3IFcr	C3IFce	C3IFcr	C3IFcra	T1M2	T1M1	T1M6	T1M9	T1PH	T1TPHV	T1M10
Straubing	284	1400	2															13.1	12.7	15.2	30.4	6.8	7.5		23.2							14.6	13.6	16.2	28.2	7.3	8.2	
Straubing	618	1400	1	13.6	13.8	14.5	18.6	7.4	6.4	16.6	22.4	14.2	50.6	6	8.5	7.4	8.5	13.8	13.4	15	23.6	5.9	6	14.8	25.5	28.2	67.7	7.2	8.4	6.5	9.1							
Straubing	716	1400	2	12.8	12.5	13.5	22.3	5.8	6.3		28.5		62	7.8	9.8		12.1	15.7	13.9	16.6	28.1	8	8.8	15.5	28.8			7	11.7	7.4		17.2	15.9	16.5	32.3	10.8	8.7	17.8
Straubing	298	1400	2	13.2	12.9	14.6	16.3	6.1	7.1	15.2	23.1			7.5	11.3	5.8	8.5	14.2	13.5	17	26.6	7.1	7.3	14.7	22.7	25.8		7	12.2	5.5	10.8	15.4	15	17.6	27.8	8.6	9.2	15
Straubing	778	1400	3															12.4	11.2	18	25.6	6.1	5.6	14.1	24.3			6.6	11.2	6.2	10.8	14.1	14	17.5	24.2	7	6.9	15.3
Straubing	401	1400	1	13.6	13.3	13.2	19.8	5.2	5.4		24.6			7.6	9.3	7.5	8.8	15.5	14.6	13.9	24.2	7.1	7	13.6	24.6			6.1	9.7	6.6	8.5	16.8	15		22.8	9.1	8.8	14.8
Straubing	368	1400	2	11.6	12.7	13.9	17.9	5.4	5.8	15.6	22.4	13.8		8.2	11	7.6	10.4		12.3	15	26.1	6	5.8	14.3	23.9	25.5		7.3	9.6	6.4	10.8	16.4	15.4	15.3	27.6	8.8	7.4	14.8
Straubing	627	1400	2	13.2	12.5	14.2	16.3	5.2	4.9	16.2	23.2	13.2	43.2	6.7	8.9	5.9	7.4	13.5	12.6	16.1	26.6	5.7	5.8	15.1	26.3	28.5		5.5	10.3	5.9	10.6	16	14.3	15.6	26	8.6	7.8	15.4
Straubing	774	1400	1															13.6	13.5	14.8	24.5	6.7	6.2	14.1	23			6.8	9.1	6.6	8.6	15.4	15.2	15.3	27.2	8	8.5	13.8
Straubing	686	1400	1	12.9	12.9	13.8	17.5	5.8	6.5	14	23.1			7.3	8.7	6.8	7.6	14.2	13.2	14.7	24.2	5.6	6.8					7.3	9			16.1	15.9	12.6			8.1	
Straubing	804	1400	1	12.8	12.7	14.4	15.6	5.8	5.7	12.7	22.5		46.6	7.4	9.1	6.7	8.2	13.8	13.3	14.6	24.2	6.2	5.5	12.9	21.5	29.5		6.3	9.9	6.6	10.2	15.6	14.9	15.8	25.3	7	7.9	12.8
Straubing	711	1400	2	12.2	12.1	14.3	16	6.8	6.3	14.2	21.6		48.5	6.9	8.5	7.8	8.8	13.2	12.6	15.9	27.2		6.1		22.5				5.5			15.9	14.2	16.2	26.9	8.9	9.4	
Straubing	643	1400	2	12.5	10.6	13.9	17.9	5.4	6.1	15.2	22.8		48.8	6.4	10.9	6.8	10.5	14.5	11.6	15.8	27.6	6.6	6.6	12.9	25.6			5.9	9.6	7	10.9	16.2	15.5	15.3	28.5	9.1	10.2	
Straubing	268	1400	1	13.2	13.6	14.9	17.7	6.2	5	17.7	22.7	12.2	47.2	6.2	9	6.4	8.6	14.7	14.3	15.4	21.5	6.4	6	14.6	27.7	24.5	28.6	6.8	9.6	6.9	10.7	17.5	15.6	16.8	25.3	7.9	8.1	
Straubing	604	1400	1	11.8	12.2	14.1	16	6.1	6.5	16.9	21.5		49.2	6.5	9.5	4.9	9.5	13.6	13.1	15.3	21.7	8.2	7.6	14.6	23.1	29.1	61	6.3	10.3	6.7	11.2	16.4	15.7	16.3	22.9	10.5	9.6	14.5
Straubing	676	1400	1	12.2	11.4	14.9	20.6	5.6	5.1	15.6	23.6		47.1	6.4	8.6	6.3	8					8.8	8.6	16.2	23.7		75					15.9	14.9	15.1	30.1			
Aesch	40	1335	2			12.5	14.8	21	6.5	6.1	24			6.1	6.5	4.2	5.8	13.4	14.4	17			7.4							6.2	9.3							
Aesch	15	1335	3	13.2	13.1	16.7	19.6	8.2	6.3	15.3	21.9			3.8	6.1	5	6.7	15.3	15.4	15.8	25.3	6.1	6.2	16.4	24.7			5.4	8.6	4.2	9.5	17.9	17.4	16.8	29.7	9.9	10.6	
Aesch	18	1335	1																																			
Aesch	5	1335	3	14.6	14.8	17.4		6.4	7.2		24.3			5.7	9.8	6.5	7.6	14.2	14.4	15.2	28.6	7.3	7.2	18	27.4			6	9.6	5.9	9	17.2			31.7	10.8	9.5	18.4
Aesch	61	1335	1	9.5	9.6				5.8									13.6	11.6		5		7.1							4.6			16.2				8.7	
Barbing	1388	1300	3	14.2	17.1	15.8	22.8	7.9	6.2	11.7	21.9	16.9	48.1	5	6.2	5.3	4.9	14.4	13.9	19	26.3	5.4	6.4	10.6	22.4			5.4	7.8	5.8	8.1	16.3	14	18.9	26		8.6	11.8
Barbing	1318	1300	2	11.8	12.2	15.8	18.5	6.5	7.1	15.4	22		50.5	6.1	7.8	5.5	7.4	13.2	13	18.3	27.9	7.8	7	13	23.5	26.4	26.7	4.2	9.8	5.3	9.4	14.5	14.4	16.1	26.6*	9	7.9	14.5
Barbing	1293	1300	1	12.2	12	15.3	17.7	6.5	6.3	13.3	22.6		48.7	6.8	7.1	6.7	8.1															14.8	13.3	14.2	24.6	6.4	6.6	14.5
Barbing	1356	1300	3	12.5	14.6	14.3	16.8	6.8	6.5	12.1	24.5	14.6	51.1	6.4	8.3	6.4	8.2	14.2	12.6	14.8	23.2	6.7	7.5	14.5	25.6	19.6	70.2	6.1	7.8	5.3	7.7	16.1	14	15	27.3	9.3	8.5	14.2
Barbing	1300	1300	2	12.5	12	15.3	15.6	5.5	6.8	14.7	22		47.8	6.4	8.9	6.6	8.3	14.6	13.1	16.4	21.2	5.8	5.8	14.6	25							16.6	15.2	16.2	27.8*?	8.6	8.9	15.2
Barbing	1285	1300	2	11.9	11.4	15.5	14.6	5.7	5.6									13.2	11.8	15	24.6	6.8	6.3		23.2		45.9	5.6	8.1	5.5	7								
Barbing	1268	1300	2															14.9	14.5	15.9	25.2	8.8	8.5	15.3	25.9			6.5	10.4	6.3	12.2	17.6	17	15.6	29.2	8.8	10.1	15.8
Barbing	1357	1300	2															14.5	13	15.4	22.5	6.8	6.4	13.1	23.6			5.2	8.7	5.5	6.3	17.2	14.4	15.3	24.9	9.4	8.9	15.2
Barbing	1284	1300	2	11.5	12.5	15.2	15.4	4.5	6		24.5		54.6	8.4	8.8	7.9	8.4	13.6	11.5	18.5	24.5	7.3	6.8	15.8	25.8		74.6	6	8.8	6.6	9.8							
Barbing	1268	1300	3																			7.5	6.5								6.3	16	14.6		26.1	9.7	9.3	
Barbing	1360	1300	3															14.8	13.5	16.2	26.4	6.2	6.1	14	23.9			6.2		7	8.4	15.9	14.9	17.4	29.8	8.6	7.4	14.5
Barbing	1387	1300	1	10.4	10.5	14.2	14.9	6	5.5	14.1	20.1		51.4	6.9	6.6	5.6	6.3	12.6	12.5	13.6	24.9	5.9	6	12.6	20.6	25.4	21.9	5.4	6.5	5.2	6.8	15.1	13.8	13.9	24.3	8.1	8	13.4
Winterthur	138	800	1															14.8	14.3	16.4	23.1	7.8	6.8	15.3	26.5		62.8	8.4	10.4	7.9	9.9	16.8	16	17.1	26.3	9.4	10	15.8
Chur	525	650	2																																			
Chur	524	650	3	9.5	9.1	15.8	17.6	4.8	4.8	14.8	21.6	10.7		5.1	4.8	4.8	4.7	11.1	10.6	18.8	24.2	5.2	5.5	12.1	23.4			4.9	7.8	5.3	7.6							
Chur	444	650	2	13.5	13.3	15.6	18.4	6.8	7.2	14.5	24	12.6	51.7	6	7.5	4.7	6	13.7	13.5	17.8	26.1	8.2	7.6	12.8	25.8	27.4	71.8	5.1	7.2	6.1	7.3	15.5	15.4	18.6	22.8	9.4	8.9	12.2
Chur	434	650	1	8.5	10.1	13.5	17.4	4.7	5	15.6	21.7			5.8	7.1	5.3	6.2	10.8	11.9	14.2	22.7		7.2									13.2	13	15.9	22.3	7.2	7.3	14.2
Chur	409	650	1	12.3	12.2	14.7	17.3	6	6.5	15.1	22.2	11.5	45.1	4.7	5.8	4.8	5.3	14.3	12.2	14.4												16.8	14	15.6			8.8	
Chur	527	650	1	13.5	14.1	15	17.2	6.8	6.9	16	21.2		52.4	6	6.9	5	7.6	13.1				7.3	7.4	13.6	23.8	28.8		4.5	8.4	5.7	8.8	15.4	15.3	16.5	22.2	8.6	8.8	14.5
Chur	477	650	2															13.7	13.6	15.9	25.5	7.9	7.9	12.9	26.3	23.6	70.6	5.8	8	6.2	8.1	15.5	14.7	15	25.5	8.6	8.9	14.3
Winterthur	15	600	2	12.4	11.6	15.4	17.2	5.8	6.2	14	23.8	13.1	49.5	5.6	6.9	6.5	6.7		13.6	16	23	6.2		13.6		23.3		4.9	8.1			15	14.6	16.1	24.2	7.5	7.8	13.8
Winterthur	13	600	1	12.8	11.8	15.8	16.8	7.5	6.3	13.4	23.1			5.8	10.9	5.8	8.4															14.1	13.9	16	22.2	7.2	8.3	14.1
Winterthur	115	600	1	11.9	12.1	13	18	6	6	16.4	24.3	11.6	50.2	5.8	8.2	6	7.8	14.5	14.5	15.7	23.8	6.3	5.9	15.9	24.1	29.1	65.6	7.3	9.9	6.4	9.6	16.8	15.5	15.8	24.8	8.9	8.5	15.9
Winterthur	73	600	1	12.2	13.6	14.6	17.5	5.5	5.6	15.4	24.7		51.2	7.9	9.1	7.1	8.6	13.5	12.3	14.6	25.3	6	6.1	14.4	25.4	27.7		6.8	10.9	6.4	9.8	15.1	14.1	14.6	26.8	9.2	8	15.4
Winterthur	9	600	1	11.4	11.1	12.9	19.2	5.2	5.2	13.8	23		50	6.5	7.4	7	7.9	12.6	11.5	12.8	26.9	7	6.5	14.1	24.4	26.7		6.5	8.2	5.8	8.9	15.1	13.3	12.9	26.6	8.1	8.5	14.7
Winterthur	28	600	2	12.4	11.5	15.1	18	5.2	5.8	15.5	23.6			5.9	6.8	6.3	7.1	13	12.8	16.5	24	6.8	7	15.3	25.6	27		6.7	10.5	7.2	9.6	14.6					8.6	
Winterthur	93	600	1															12.6	12.5	13	25.8	5.3	6.9	15.2	23.2	25.8		6	11	6	9.8	13.5	12.6	14	23.8	7.6	7.8	16.7
Winterthur	26	600	2	11.4	11.5	14.2	17.2	5.2	6	16.3	22.8	11.5	44.1	5.7	8.4	5.2	8.8	13.5	12.8	13.8	25	5.6	6.5	15.2	24.9	24.5		6.8	10.7	6.8	10.1	15.9	15	16.4	22.9	8.5	9.8	15.4
Winterthur	67	600	1	13.3	12.8	14.3		6.2										11.8	10.5	15.9	20.8											15.1	14	15.7	24.6		8.2	
Winterthur	52	600	3	11.7	12.1	13.3	17.1	4.9	5.1	15.2	24.1	15.5	49.2	7.5	9.6	7.9	8.3	15.9			25.7	7.8	6.7	15.8	21	28.9	68.2	6.6		7.2	9.6	13.8	12.9	14.6	22	5.9	6.7	15.1
Winterthur	8	600	1																10.6	15.9	22.5	5.5	5.4	15.5	26.9	20.3		6.6	8.8	6.5	10.6	13.6	12.1	16.8	25.8	5.9	5.8	15.1
Winterthur	21	600	2	11.9	12.7	13.4	15.5	4.9	5.2	15.6	22.6	14.8	48.8	5	9.1	5.4	8.3	14.1	12.4	14.5	22.8	5.6	5.8	14.3	23.3	26.9		5.6	10.2	5.8	10.5	16.1	14.6	15.2	24.3	7.9	7.9	15.3
St.Johann	282	228	3	10.9			17.3	16.8	4.9	4.6	14.6	21.7		46.7	6.3	5.8	5.8	10.8	10.3	16.3	24.9	4.8	5.7	14.2	26	24.2	22.2	5.7	9.2	6.2	10.4	13.8	11.6	16	29.4	7.1	6.6	15.3
St.Johann	244	212	2	11.8	12	12.8	17.8	5.3	5	13.2	24		42.2	7.5	7.8	6.9	9.6	10.7	10.6	13.4	20.9	5.5	4.8	14.6	26.4			4.4	9.3	5.6	9	13.2	12.2	12.2	23	6.7	6.9	14.4
St.Johann	300	196	2	13.3	12.5	15.4	19	7.7	7.1	13.3	25.3		53.3	6	7.9	5	5.9															16.5	15.9	14.5	27.2	7.3	7.3	14.2
St.Johann	1404	193	2	11.4	11.5	13.9	18.2	5	4.9		21.4			5.3	6.2	5.2	6.2	12.9	12.1	15.8	26.5	5.3	5.3	11.8	23.5			5.4	8.2	5.2	7.3	14.1	13.2	15.9	26.8	9.7	6.7	13.1
St.Johann	482	192	3	12.1	12.4	15.5	18	6.6	5.3	15.8	22.8	13.4	47.9	5.3	9.5	7.8	8.1	13.4	12.2	15.2	25.2	6.7	6.9	14.3	24.6			5.9	10.6	6.3	9.9	15.6	13.4	14.6	25.9	9.1	8.1	15.6
St.Johann	317	189	2															13.4	13.1	15.9	25.9	6.6	6.6	16.2	27.8			6.7	10.2	7.3	9.5	14.9	13.4	15.7	28.6	8.8	7.9	16.4
St.Johann	1104	187	1															12.8	11.3	14.6	26.3		7.5		29.5							16.2	12.3	17.7	32.1	8.8	8.6	15.6
St.Johann	41	186	1	12.9	13.1	14.1	19.3	5.8	6.2		25.1		56.6	5.1	7.5	6.4	7.4	13.2	12.2	16.9	23.8	5.5	6.5	14.6	24.1	29.6		7.2	10.1	7.3	9.6	15.2	14.4	16.8	26.5	9.2	8.6	15.8
St.Johann	56	186	1	11.8	12.4	14.9	17.7	6.6	6.1	13.2	22.8		56.2	4.9	6.2	5.1	6.5	11.8	10.5	17	25.7	5.8	6.4	11.4	23.8			5.8	6.1	5.9	7	14	13.4	16.4	25	7.5	6.7	13.9
St.Johann	60	185	1	12.4	12.4	13.8	13.7	5.3	4.8	16	20.8		47.1	4.8	8.2	6	8.7	13.7	12.8	13.7	21.2	6.6	6.2	12.4	22.2		30.3	6.5	9.3	6.6	9.1	14.7	14.4	15.3	24.8	8.6	7.8	12.8
St.Johann	16	184	1	10.3	10.5	14.2	17	4.8	5.1	15.2	23		53	7.1	8.8	7.6	8.2	11.6	11.4	14.2	22.5	6.1	5.5	14.8	24.8		62.4	6.4	8.3	6.2	9.8	13.1	13.2	16.5	24.5	6.2	6.4	15.8
St.Johann	276	179	1	13.1	12.8	15.1	14.9	5.7	5.9	15.4	23.2	12.3	53.3	6.8	7.4	6.8	7.8	13.9	13.1	16.3	23.2	6.6	5.8	14	25.1		60.8	6.8	10.3	7.2	10	16.6	15.3	15.6	26.2	8.2	9	15
St.Johann	266	178	1	11.8	11.4	12.6	15	5.3	5.8	15.5	24.6		50.8	8.1	7.4	6.8	8.4	13	12.9	14.6	19.8	6	5.9	14.7	26.8	27.3		8.2	11.9	7.2	11.9	15.7	14.1	15	21.2	7.3	8.3	15.1
St.Johann	1320	176	1	11.7	12.9	11.8	15.6	4.6	4.8	13.1	22.5			5.8	7.8	4.3	8.5	12.6	11.2	13.8	23.9	5.7	5.4	13	25			6	8.3	5.5	8.5	15	14.3	13.2	24.4	7.1	7.8	13.8
St.Johann	1710	175	1	14.8	13	17.2	21.2	7.1	8	13.9	24.1	13.1	53.6	6.2	6.8	6.1	7	16	15	19.2	26.2	7.4	7.3	12.9	24.5	24.7		6.7	7.6	5.2	8.4	17.6	15.7	19.9	27	9.9	9	14.2
St.Johann	632	165	1																																			
St.Johann	527	163	1	10.9	12	14.1			5.1					6.3	7.5																							
"Geneva"	6	*	3	11.4	11.2	15.8	20.2	6.4	6.4	14.8	24.8		52.1	6.6	9.7	5.8	10.7	13.5	12.2	16.8	25.6	8.2	8.5	14.1	26.1	25.2		6.5	9.8	6.9	10.7	14.8	13.9	16.6	25.4	9.1	9.4	14.8
"Geneva"	15	*	3		11.3	12.8	24.2	6.5	7.3	17.3	24.6			7.2	8.4	7.3	8.4	14.2	12.9	18.4	25.5	6.5	7.5	15.7	26.6			7.3	11.8	7.8	10.4	15.9	14.9	17.9	25.5	8.6	8.7	17.2
"Geneva"	4	*	3	13.3				7.4	6.8	17.6	22.2	25.5		7.1	9.8	5.4	9.8	15.1	14.1	16.5	25.4	8	8	16.9	24.1	22.8		7	11.6	7.5	10.4	17	14.2	16.8	27.1	10.4	10.2	16.7
"Geneva"	2	*	3	12.5	10.4	16.5	21	6	7.1	14.3	24			6.7	7.8	7	7.5	13.8	12.7	16.8	23.2	6.3	8	15.3	27.1			6.5	10.9			15.3	13.8	16.9	25.5	9.2	9.5	16.1
"Geneva"	19	*	2	15.7	14.5	15.9	19.9	6.3	6.4	16.4	24.4	14.6	53.5	7.7	8.1	6.5	8.6	14.6	13.4	15.4	24.2	6.4	6.5	15.6	26	30.7	62.8	6.3	9.8	7.2	9.7	17	15.9	15.5	26.2	8.7	7.1	14.9
"Geneva"	17	*	2	13.5	12.8	15.9	17.9	6.5	6.9	15.5	23.2	17.8	51.9	7.8	9.8	7.3	8.2	13.9	13.4	16	25	5.5	6.2	14.6	25.6	28.3		6.8	10.2	6.3	10.2	15.6	15.7	16.3	26	9.3	10	17.4
"Geneva"	11	*	3	13.3	12	14.6	17.8	6.7	7	16.6	23.8	17.2		6.9	9.5	7.3	7.7	14.6		14.8	26.1	6.8	7	15	24.4	22.7		6.4	11.1	7.4	10.9	16.3			27.8	8.8	8.5	15.9
"Geneva"	5	*	2	14.9	15.5	15.9	16	8.1	8.3	15.1	23		52	6.9	8.2	6.5	7.9	14.8	14.5	16.8	23.4	9	9.4	14.5	24.5	20.9		6.8	9.5	6.7	9.6	16.6	15.8	16.3	27.6	11.4	9.6	15.2
"Geneva"	7	*	1	13	13.1	14.1	15.2	6.8	6.2	15.9	23.7	13.8	54.5	7.2	9.8	7.4	9.2	14.4	14.2	16.8	22	6.4	6.9	14.8	24.9	27.5		8.2	11.7	8.2	10.7	15.5	15.1	16.6	24.1	9.2	9.2	15.3
"Geneva"	16	*	2	13.2			20.4	6.8	6.6	16	25.8	16.5		8.1	8.7	8.1	7.8					7.1	6.6	15.7	27	29		6.9	9.5	6.8		17.8	16.5	14.3	25.3	8.4	8.4	16.8
"Geneva"	1	*	1	14	12.8	15.5	19.5	6.3	6.5	17.3	27.4				10.4	6.6	10.2	14.2	13.8	16.8	25.8	5.8	5	16.2	28.9	26.8		7.5	10.6	7.6	10.8	16.8	14.3	16.5	24.1	7.7	8.1	17
"Geneva"	4	*	1	13.5	13.9	13.5	17.8	7.1	6.9	15.8	24.8			7.4	9.5	7.3	8.9	14.8	14.5	14.2	25.6	7.4	6.3	14.2	26.6	25.9		6	10.9	6.8	11.4	17.2	16.3	14.2	27	9.7	8.7	15
"Geneva"	10	*	1	14.6	14.2	14.8	18.2	6.8	6.3	18.5	27.2		56.8	8.6	10.6	7.4	9.9	16.6	15.2	16.9	25.8	7.1	7.1	15.8	28.1		79.8	7.8	10.3	7.9	10.2	18.6	17.3	17.1	26.4	8.9	8.9	15.5

Individual / Sample	Specimen number	T1M11	T1SPL	T1TPW	T1Fcr	T1Fca	T1Fcr	T1Fcra	T2M3	T2M1	T2M6	T2M9	T2PH9	T2PH	T2M10	T2M11	T2SPL	T2TPW	T2Fca	T2Fcra	T10M3	T10M1	T10M6	T10M9	T10PH9	T10PH	T10M10	T10M11	T10SPL	T10TPW	T10Fca	T10Fcra	L1M3	L1M1	L1M6	L1M9	L1PH9	L1PH
CroMagnon	2																				20.2	20.4	25.1	27	12.8	12.5	14.9	14.6		54.2	12.2	11.9						
Tevlec	1	19.4	28.2	68.2		9	4.8	9.5	20.2	16.6	21	24.2	10	10.3	15.2	19.9		55.3	12.9	9.7	20.1	19.5	22.8	29.1	13.9	15.2	20	18.9		59.2			24.8	20.1	26.1	32.2	14.8	14.6
Vaihingen	115																																					
Vaihingen	93																				24.4	21	27.6	31	15.2	15.8	16.4	17.3	18.6		12	13	26.8	25.1	30	35.7	12.6	14
Vaihingen	45																				21.7	21.6	26.3		14.2	13.8	15.1	17.4	21.9	47	10.9	9.4						
Vaihingen	87		23.6		5.8	9			18	16.9	21.6	22.9	9.8	10.3	15.4	15.5		55	12.1	11.7																	
Vaihingen	14																				21.1	21.1	24.6	28.7	14.7	14.5	15.6	16.2	23.6	44.4	13.1	12.5	24.9	23.4	25.2	32	14.5	15.1
Wanderslaben	2241																				21.9	20.2	25.2	30.2	15	13.6	15.4	15		55.4	8.6	8.9	25.8	26	27.3	36.2	15	15.5
Wanderslaben	2124	19.8	28.5		5.5	10.5	6.1	9.6	18	16.9	20.7	24.5	11.2	10.2	15.8	16.5	16	54.2	10.3	10.2	20.6	18.6	25.5	32.3		15.1	13.4		19.7			10.2	24.1	22.4	27.1	34.6	13	
Wanderslaben	2299	19.2	25.8	72.6	4.8	6.9	5.3	7.9	17.6	16.5	24	24.9	10.3	11.3	14.9	15.6		50	9.3	8.7	23.1	21.2	23.9	26.5	15.3	14.9	14.7	15.7		55	10.6	11.5	26.4	24.4	26.9		14.3	14.1
Wanderslaben	2243	17.7				10.6		10.6	18.1	17.5	21.8		10.5	10.1	16.5	14.6					19.4	17.6	26.1	29	11.9	12.9	15.8	15.9			11.1	10.4	25.2					13.7	14.5
Wanderslaben	2230	20.5		63.2	6.1		6.1	7.3													20.8	19.3	24.2	26.6	13	13.2	16.8	16.5	18.9	47.6	11.6	12.8	25.2	24.5	27.3	35.4	13.8	13.8
Wanderslaben	2214																																					
Wanderslaben	2250	21		71.4	6.9	10.6	7.3	9.5	17.6	16.4	21.2	22.1	8.9	9.3	15.9	16.5	18.9	47.6	11.5	12.8	21.8	19.6	22.2	24.8	10.8	10.9		15.1			9.9	24.9	21.4	25.2	29.9	13.9	13.3
Wanderslaben	2200																																					
Wanderslaben	2207										18	22.4	9	8.4	17.2	15.2		58.1		8.5																	
Wanderslaben	2146																																					
Wanderslaben	2295	19.2			5.6	8.6	5.1														18.6		28.5	27.7	12.7	13.5	13.4	14.7	18.2	53	9.3	12.1	24	22.9		36.1	14.1	14.1
Wanderslaben	2300																																					
Wanderslaben	2293																				23.1	22.1		28.7	13.8	12.1	15	14.5		53.2	11.1	11.9	27.5	25.8	28	33.5	14.5	14.2
Wanderslaben	2294	18.5		56.6		8.5		10.6	17.7	16	24.5	25.1	10.4	11.5		15.6		61.2	9.8	8.6													25.4	24.6	27.5	36.2	14.4	14.1
Wanderslaben	2289	19.8	33.1		5.2	10.8	5.1	10.6																														
Wanderslaben	2137																				23.7	22.7	25.4	29.5	14.6	15	16.3	16.4		55.6	12	10.3	27.5	25.6	28.3	34.5	15.1	15
Wanderslaben	2195																				21.8	20.3	23.2	27.9	13.6	13.5	15.1	17		47.6	11.2	8.8	26	23.8	25.4	32.6	13.5	14.5
Wanderslaben	2155	20.4	28	68.8	5.3	9.6	5.4	9	19.6	18	22.4	24.5									23.8	23.2	26	29.7	14.4	15.6	15.7	16.3	24.1	46.3	10.5	10.1	28.1	24.4	27.8	36	15	14.9
Wanderslaben	2174								18.1	17.8	20	24.2		10							22.2	19.6	25.2	30.7	14.2	14.4	17.2	18.1	23.4	54.1	11	12.6	26.2	22.3	28.3	34.1	11.1	12.1
Wanderslaben	2112	19.7	29.5	71.2	6.5	9.3	6.2	9.3	19.9	16.6	22.5	24.1	11.1	10.5	14.8	15.8	14.6	57.2	11.2	12.2	24.9	22.4	24.9	29.7	16.2	16.2	16.7	18.3		49.5	8.6	9.5	29.6	26.9	29.3	39.3	15.6	15.3
Wanderslaben	2225	21.9	26.4	71.3	6.8	10.5	7.4	10.3	19.2	17.1	22.9	24.5	10.9	10.4	16.4	16	9	58	10	9.1	23.8	23.2	26	29.7	14.4	15.6	15.7	16.3	23.4	54.1	11	12.6	26.2	22.3	28.3	34.1	11.1	12.1
Wanderslaben	2189	21		71.8	6.5	8.4	6.1	8.7	21.3	19.4	21.1	23.2	12.6	11.5	16.5	17.2	9.5	61.5	13.2	11.3	22.2	19.6	25.2	30.7	14.2	14.4	17.2	18.1		49.5	8.6	9.5	29.6	28.2	26.9	39.3	15.6	15.3
Wanderslaben	2187	23.6	27.5		6.2	9.2	7.1	9	17.6	16.2	19.5	24.5	11.1	9.9	16.7	20	25.1	67	11.4	9.9	24.9	22.4	24.9	29.7	16.2	16.2	16.7	18.3	37.7	65.8			27.3	23.6	28.6	31.7	13.4	12.8
Wanderslaben	2234																						24.6	30.2									26.4	24.5	29.3	39.6	14.1	15.5
Wanderslaben	2114	19.5			6.3	9.1	6.5	11.1	20.3	18.7	24.1	26.5	10.5	10.6	15.6	14.9			6.7	6.2	22.8	23	27.5	32.5	13.8	15.1	16.5	16.9	24.4		7.9	11.9	25.2	24	25.7	29.2	14.1	15.1
Wanderslaben	2239												11.3	10.5	14.3	14.5					21.1	20.6	22	25.1	13.6	14.5	14.8	14.7			8.1	10.2						
Hoxkic	6	19.1			4.5	6.4	5	9																									26.2	24	28	29.6	15.1	16
Ekrumtlea	1																				23.6	22.5	26.2	33.5	15.3	15.4	17.2	17.2	24.4	49.6	12	12.5	31.3	28.1	28.2	35	16.3	15.3
Hainburg	21126								19.8	18.4		25.1	11.2	10.5	14.9	16.7		53.8	10.1	8.9	22	20.8	25.8		15	14.8	14.6	15.3	22.6		13.4	12.6	28.5	26.8	31.8	34.2	14.4	15.7
Hainburg	21058								20	18.8	22.2	24.8	10.8	11.8	14.9	14.1	15.6	60.6	12.9	12.7												31.2	25.2	27.8	33.8	14	13.2
Hainburg	21076								20	19	21.6	22.8	11.2	11.2	15.2	14.8			11	10.3	20.6	20.4	24.8	30.2	13.7	12.9	16.2	16.8		61.3			26	25.3	28.8	35.8	14.8	15.8
Hainburg	21058	18.9	29.9	69.5	5.5	10.6	6.3	10.8			17.6	21.7	23.2	10.4	10.2	15.9	13.3	13.8	59.7	14.2	16.2												26	27.1	27.9	36.5	15.9	17.1
Hainburg	21116	20		68.8	5.8	9.8	6.7	12.2													19.6	18.2	22.8	29.6	11.8	11.2	14.2	16.4		53.2	10.8	11.2	26.6	25.4	24.5	38.8	14.9	15
Hainburg	19055								17.2	16.8	20.1	25.7	9.3	10.6	14.8	16.4		51.6	10.6	10.8													23.4	23.3	23.2	40.1	14.6	14.8
Hainburg	9715																				21.4	19.8	26.8	29.8	12.6	12.2	16.6	19.3			12.8	11.8	25.3	24.4	26.2	34.3	13.6	12.8
Hainburg	13036	21			7.5	11.4	8.6	9.7	18.3	17.3	20.1	24.2	9.8	8.7	17.6	18	15.8	57.6	14.1	9.8	20.7	20.2	28.6	30.8	12.6	14.2	14.9	17.6	24.1	57	13.8	12.4	25.5	25.8	30.6	36.3	12	11.8
Hainburg	21051	19.5	32.2	74.9	6.9	11.1	7.1	10.6	17.1	15.7	24.5	23.4	10	11.4	14.6	15.9		66.9	11.5	12.2	22.8	21	23.6	29.6		13.9	14.4	16.2	22.6	45.9	13	10.8							
Hainburg	9881	19.5	22		5.8	9.4	4.9	9.3	19.1	18.1	19.3	23.5	9.4	10.1	14.6	17.2	26.2	57.9	13	13	25.4	24.5	26.8	35	16.8	16.8	16.2	18.2		52.2	10.6	10.4	32.2	29.1	30.9	43.1	17.2	17.4
Hainburg	21080								22.2	21	24.5	27.1	12.6		16	15.8		64.4	13.6	10.8	18.7	18.2	23.3	27.8	11.5	11.2	14.6	18.2	19.2	55.6	11.7	11.6	25	22.8	24.9	35.1	15.2	15.5
Hainburg	9885	19.9		65.8	6.1	10.1	5.8	10.3	18.6	16.5	19.8	24.8	10.6	10.6	15.6	16.1	16.8	49.6	10.9	11.2	22.9	20.4	26.1	35	14.2	14.7	15.3	20.5	24.9		12.4	12.5	27.1	23.6	29.8	36.3	14.6	14.2
Hainburg	9750	17.6			6.8	10.8	7.2	9.8	19	18.1	24.2	28.6	8.9	8.5	14.8	20.2		65.2	14.7	11.9	20.3	20.2	24.4	27.7	12.5	13.2	15.9	16.2			14.2	12.6	25.2	23.6	26	31.3	15.6	15.4
Hainburg	12139	19.6	27.7		5.9	8.8	5.5	10.1													22.6	20.6	25.6	33.1	14.8	14.7	16.1	19	26	49.2	12.3	12.6	28.2	26.8	28.1	37.8	14.4	16
Hainburg	13117	22.3	24	74.1	5.8	12	6.1	10.6													20.4	20.9	27	28.8	12.9	13.6	11.7	13.5	30	55.2	10.6	8.8	27.5	26.4	28	37.5	14.1	15.3
Hainburg	13083								15.9	16		28.1	8.5	9.8	15.6	19.8	24	60.8	11.3	11.8	21.5	20.8		33.2	11.9	12.8	15.8	19.3			13.2	11.6	23.8				32.6	12.9	13.2
Hainburg	9729	18.1		58	7.2	12.9	9.2	12.8	17.7	16.2	18.8	22.3	9.7	8.8	14.6	16.2		54.9	13.2	11.7	19.1	17.8	20.3	28.3	12.6	12.2	15.1	18		12	11.4	23.5	21.3	24.6	30.5	12.8	12.3
Hainburg	12199		25.2	63.8	7.3	10.1	6.4	10.2													13		25.2	32.2	14.4	16.5	14.6	16	23	59.4	9.5	9.2	27.6	25.9	27.3	35.8	14.2	15.2
Hainburg	12137	20.7	29.2		6.2			6.4	18.6	19.2	23.5	27.4	11.1	11.4	15.8	15.9	12.2	59.2			20.5	20.1	24.5	30.6	14.1	14.8	15.2	15.1	19.1	50.8	10.8	11	27.5	24.8	28.8	34.7	15.8	15.2
Hainburg	8707								19.5	18.2	20.9	23.2	10.5	9.3	14.4	18.2			12.8	12.3	22.1	20.6	26.3	27.8	14.5	14.8	14.2			52.4	10.8	9.8	27	27.6	26.8	33.8	15.9	15.8
Hainburg	21111	19.1		57	6.8	9.1	5.9	9.8													21.5	22.3	24.1	34.6	13.4	13.6	10.8	16	24.7	50.6	12.1	9.6	28.6	25.8	30.9	37.7	17.1	18
Hainburg	21065	19.5		72	7.3	9.8	6.1	9.8													21.5	21.7	26.4	28.6	14.4	14.8	16.8	16.7	22.2		14.8	13.8	27.5	28.4	27	35.2	13.9	13.5
Hainburg	21067								19.2	18.8	20.2	24.3	11.2	10.8	17.4	17.6	17	58.4															27.2	24.1	31.7	36.2	14.9	14.8
Straubing	631	22.2			6.9	11.7	6.9	12.3	16.5	16.9	22.4	23.2	9.9	9.4	16.5	17.2					19.5	19.9	28.9	26.6	11.6	11.9	13.6	16.5	24.9	62.8	12.8		26.3	25.4	26.8	37.7	14.2	14.8
Straubing	780								18.4	16.1	24.2	23.8	11.7	10.2	15	15.9	13.5	65.2	13.2	13	22.7	22.1	28.2	29.8	14.1	14.1	15.2	15.2		54.9	13	13.3	24.1	22.8	23.6	31.9	13.5	14.1
Straubing	415	21.8		69.5	7.4	10.9	7.5	10.5	19.1	18.1	24.1	23.6	9.7	10.8	15.8	14.9		54	12.4	10.6	21.8	21	22.5	29.6	15	14.3	19.6	20.1	21.8	51.2	14	14.2							
Straubing	288	24.1	23.8	67	4.8	10.9	5	12	17.8	17.1	19.1	24.1	11.9	10.9	19	19.6	11.6		12.1	11	21.1	21	31.4	32.4	13.2	13.5		17.6			13.9	15.1	26.9	25.6	30	40.5	13.6	14.2
Straubing	741	21.2	27.6	76.5	6.9	9.8	7.1	10.6	19.3	16.9	26.7	29.6	11	10.3	16.1	16.4		57.2	11.2	9	19.9	17.6	26.1	30.8	11.4	10.5		17.7			13.5	10.4	25.6	24.6	26.8	35.7	13.6	14.4
Straubing	734	22.2			6.9	12.2	6.4														22	16	32.8	30.2	13	14.2	13.5	17.2	20.8	55	15.6	12.8				36.2	15.6	14.1
Straubing	394	18.8							20.2	18	24.6	23.9	9.8	10.8	15	15.6		55	10.2	10.5	20.5	19.7	22.6	29.4	13.6	13.2	16	18.4		42.6	14.2	15	26.2	22.8	28.5	28.2	15.3	13.4
Straubing	725								19.6	17.3	22.3	24	10.2	10.6	16.1	19.2	7.4	66.9	14.9	14.6	22.5	21.9	25.4	28.8	14.7	15.2	17.3	17.8					22.9	19.2	26.2	34.8	12.1	13.4
Straubing	810	22.6		74.7	8.8	11.8	8.4	11.2	20	18.1	21	25.3	9.7	11.6	17.4	18.6	6.8	56.3	11	14.8												25.6	24	27.2	38.9	13.1	14
Straubing	744	22.7		72.2	7.1	11.9	6.2	11.8	16.7	16.2	20.2	23.2	10.5	10.3		17.7		57.2	10.7	10.9	22.5	20.8	27.5	31.7	16.3	16.2	16.4	18.1			12.3	13.2	28.2	24.2	27.8	38.1	14.5	13
Straubing	462	22.3	20.6		5.1	9.3	5.3	9.8	18.5	17.8	22.8	24.6	9.8	10.1	14.9	17.4			13	13	22.4	23	26.4	29.8	14	12.8	17.5	20	22.5	58.6	12.3	14.6	24.5	22.6	28	36.8	13	15.8
Straubing	351	24.2	30.2	74.8	6.3	10.2	7.2	11.3	20.2	18.8	22.9	25.3	10.3	10.8	17	18.3	15	61	11	11.3	18.5	18.2	27.2	31.5	11.5	13.5	15.9	16.2	28.7	55.5	13.3	12	24.5	22.6	28	38.6	13	15.8
Straubing	474								17.5	15.5	24.6	25.8				13					21.9	21.8	27.5	28.6	14.1	12.8	15.8	18.9	24.8	57.3	13.2	13.1	27.9	25.8	30.9	33.7	13.9	16.7
Straubing	614	20.1	32.9		5.9	9.5	6.1	9													22.8	21.5	28.5	31	14.1	13	14.9	17.3		60.6	13.2	11.1	27	23.9	25.6	37.8	14.1	15.3
Straubing	611	21.6	24.8	72.4	7.3	11.3	7.8	11.3	21.1	18.7	24.1	24.9	11	11.2	15.1	15.8	15.4	65.1	12.2	11.6	21.9	22.6	24.9	27.5	12.9	13.5	15.4	17.5		50.6			24.1	23.2	26.1	35.4	13.7	13.8
Straubing	624	21.2	28.7	69.1	6.3	9.2	6.8	10.6	20.1	19	21.4	23.1	10.1	10.6	16.4	16.9	19.2	56.8	13.8	11.5	20.4	17.8	26.2	32.2	14.2	14.6		17.3					25.8	24.2	26.5	39	13.4	13.4
Straubing	305	21.8		58.2		11.9			18.8	17	24.2	27.2	10.9	11	15.2	17.6					21.6	18.7	26.1	30.8	13.8	13.6	13.5	15.9	15.1	54.1	12.2	11.5	24.4	23.6	23.2	33.4	13.3	13
Straubing	279	20		56.8	6	9.5	6.1	8.9	19			23.6	10.2	10.4	14.2	15.2	17.6	55.5	12.8	12.1	20.8	17.7	25.1	28.6	12.3	13.3	14.9	17.6		50	12.5	11.1	27.2	26.6	27.6	36	13.3	14.1
Straubing	792	20.5		68.1	6.9	10.8	6.3	11	17.1	16.3	20.5	23.2	8.6	8.6		15		45.5			22.8	22.2	25.1	29.8	13.4	14.4	15.3	16.4		42.1	13.6	14.7	27.8	23.6	31.5	42.6	15.8	16.1
Straubing	468	21.6			7.8	12.3	6.2	11.6	19.2	17.1		22.6	9.6	10.1	15.4	16.1	13	55.2	13.1	13	22.2	21.5	28.1	35.3	15.4	14.7	14.9	17.6	24.8	47.2	11.5	12	24.8	23.1	27	32.4	15.3	15.1
Straubing	481	22.7	27.4	77.3	5.8	7.9	6.8	9.5	20.5	17.2	24.1	30.1	11.5	11.8	15.4	16.1	13	55.2	13.1	13	20.4	18.6	27.8	29.1	13.8	13.2	14.3	17		57.4	12	11.3	25.4	23.8	26.3	38.5	13.7	15.3
Straubing	501	19			5.8	10.8	5.8	9	18.4	17	25.1	25	12.4	12	16.3	16.9					21	19.6	24.5	32.4	13	13.2	15.7	16.6		54.8	12.8	12.9						
Straubing	786	20.5	24.9	69.2	5.8	10.6	4.8	9	17.5	15.1	19.2	25.8	9.8	10.3	14.9	16.4		61.4	12.8	11.4	23	22.1	22.8	33	15	16.2	15.7	18.6		53.6	12.4	12.1					33.7	13	13
Straubing	795	20		76.5	5.8	10.3	6.1	10.5	21.4	20.2	23.2	26.2	11.5	12	14.4	15.8		56.9	13.3	13.1	21.2	22.3	27.8	31.3	14	13.8	15.8	17.7			11.9	10.8	26				32.2	12.6	13.9
Straubing	377	21.2	25.6		5.8	9.5	6.9	10.6	18.9	17.2	26.4	26.2	10	9.7	15.8	17.5			14.6	13	22.2	21	24.5	28.2	13.4	12.8	15.8	18.6			12.4	11.9	25.4	24.6	28.4	32.8	14	13.7
Straubing	248	21		60.8	6.1	12.5	7.2	11.8	20.2	17.4	21.6	22.8	10.6	10.4	17.3	17.5		54	12.3	12.3	20.5	19.8	27.5	29.2	14.3	14.3	17.6	16.3	25.8	49	12.5	11.9	25.9	24.5	28	32.6	14	13.7
Straubing	484	18.9		69.2	5.2	9.8	6.3	8.9	18.6	17.9	24.2	24.8	10	10.8	14.9	15.2		57.8	12.8	13	19.2	19	21.6	26.9	12.3	13.7	15.9	17.9	25.6	50.7	12	10.8	23.4	23.1	21.7	31.6	11.9	11.8
Straubing	425								18.6	16.3	16.9	21.9	10.6	10.5	15.4	17.2	16.6	59.6	13.7	11.8																	

Individual / Sample	Specimen number	T1M11	T1SPL	T1TPW	T1IFlce	T1IFlce	T1IFrcr	T1IFrce	T2M2	T2M1	T2M5	T2M9	T2PH2	T2PH1	T2M10	T2M11	T2SPL	T2TPW	T2IFlce	T2IFrce	T3DM2	T3DM1	T3DM5	T3DM9	T3DPH2	T3DPH1	T3DM10	T3DM11	T3DSPL	T3DTPW	T3DIFlce	T3DIFrce	L1M2	L1M1	L1M5	L1M9	L1PH2	L1PH1
Strasbing	284	18.6		73	6.3	8.1	5.6	8.3	17.6	17.4	23.6	26	10.2	10.8	15.6	16.8					20.5	18.5	22.8	32.6	14	14.2	14.5	17.2		58.8			25.2	24.1	26.1	38.2	13.5	14.6
Strasbing	618																				24.8	21.2	26.5	32.5	16.8	15.9	16.8	18.7	22.6		10.6	9.5	28.3	26.3	27.4	35.6		15.1
Strasbing	716	24.9			5.6	11.4	7.2	11.9	20.2	19.3	22.8	28.2	10.8	10.6					15.2	13.8	22.6	21.2	27.9	34	14.6	14		21.9					23.8	24.8		43.2	14.9	
Strasbing	298	20.5	19.4	61.9	6.8	13.8		13.5	16.6	16	25.8	24.9	9.7	8.9	16.2	18.3	10.8	59.7	15	12.8	21.9	20.4	26.5	32.8	12.8	13.6	16.2	19.2	21.2	44	15.1	14.8	25.8	24	29	34.1	14.8	15.1
Strasbing	778	22.2			6.9	12.8	6.8	10.9	16.1	15.1	24	22.6	9	9.3	15.8	17.5		55.8	12	12.3	20.1	18.7	24.8	29.2	13.7	13.8	16.7	18		55.8	12	12.5	23.2	22.8	24	33	11.4	13.2
Strasbing	401	21.1		72.6	5.9	10.9	6.5	10.2													22.1	20.7	28.6	27.4	13.3	14.2	15.6	17.8		54	13.1	12.9	27.7	25.1	27.7	34.2	14.8	15.4
Strasbing	368	20	28	64.6	6.9	10.4	7.2	11	18.5	14.3	24	24.2				13.2					21.4	20.2	29.6	29.8	14.5	15.2	15.1	14.9			13.4	11.6	26.2	24.4	27.6	34.3	14.3	16
Strasbing	627	22.1	22.6	69.5	7	12.4	6.4	11.9	20.6	18.4	24.8	21.8	10.5	11.8	15.9	16.2	10.9	54.4	15.1	15.4	21.6	20.5	26.3	25.2	12.6	12.8	15.6	17.6		55.2	14.2	13.6	27.9	25.5	26	33.9	13.1	12.6
Strasbing	774	20.5		67.2	6.1	8.6	5.8	8.5	16.9	15.6	21.3	24.5	9.1	9.8	14.3	14.8		45.5	12.5	11.4	22.3	21.1	21.3	30.5	14.3	13.8	14.6	16.1			11.1	11.5	26.5	24.2	25.2	35.8	14.8	14
Strasbing	686			74.6					19.1	16.9	21.6	23.9	10	10	15.3	16.5	13.8	57.2	12.3	13.8	21.1	20.8	24.1	28.8	12.2	13.1	15.5	16.3	24	58.4	12.1	12.2	25.5	22.8	23.3	34.3	14.5	13.8
Strasbing	804	18.8		69.5	6.8	8.9	5.6	8.6	18.6	18.2	22.1	23.9	9.9	11.4	14.9	15.7		53.5	13	12.5	22.9	21.8	25.3	30.6	13.2	13	15.1	16.8		54	14	13.1	27.8	26.9	26.1	33.3	14.8	15.1
Strasbing	711	20.3		73.7	6.5		6.3		19.3	16.5	22.3	28.8	10	8.1		16.8					22.3	19.8	25.3	33.8	12.9	13.8	15.7	17.8		57.4	12.6	13.2	25.6	24.5	28.8	37.8	13.3	15.2
Strasbing	643	21.7							21.1	18.4	25.5	27.2									22.6	21.6	26.2	26.2	14.6	13.8	15.6	18.3					27.7	26.2	23.5	35.5		16.9
Strasbing	288	23.7			6.1		7.6	10.1	19.2	17.3	23.9	26.2	9.5	9.8	15.2	17.6		58	10	13	21.6	21.3	26.7	31.2		14	16.2		64		11.8	30.1	27.2	30.8	38.3	17.4	18.1
Strasbing	604	20.1	22.6	72.4	6.3	11.1	7.6	11.4	20.4	17.5	24.2	23	11	11.4		16		59.8			21.6	20.8	25.6	28.3	14.5	14.8		17.4			26.5	24.8	27.2	32.1	15.3	16
Strasbing	676				6.2	11.9	6.6	11.2	18.8	16.2	23.9	25.2	9.1	9.6	19.1	20.4			11.9	14.2	19.2		26.8	29.6	13.6	13.6		19.5			27	25.1	26.2	38	16.1	15.8
Aesch	40																														26.5	28.6	32.9				12.6
Aesch	15	22.6			6.2		6.5		19.3	16.5	24	25.4		12.1							21.7	21.2	28.4	31.5	15.6	14.7	15.8	14.5					25.5	24.8	25.3	36.8	15.6	14.8
Aesch	18																														28	27.4	28.2	38.4	17.9	17
Aesch	5	25.5			6.6	11	6.6	10.4																													
Aesch	61						5.1																								27.5	26.8	32.4	39.1	15	14.8
Barbing	1388	19.5		72		6.5	4.4	7					10.5	11.2		14.5																			15.3	16.5
Barbing	1319	20.5		69.9	5.5	7.4	5.4	6.8	18.8	18.1	22.2	26.9									22.8	22.1	27.9	32.2	15.7	14.4	15.9	17.3			12.1	10.7	27.8	24.9	27.9	36.9	15.3	16.6
Barbing	1293	25.7		68.4	6.2	8.4	6.5	8.2	19.8	17.3	22.2	24.8	10.8	10.6	17	15.7		59.2	12													27.7	25	26.9	36.4	14.1	13.6
Barbing	1356	22.8	23	76.6	6.2	7.1	4.6	8.3	18.1	17	21.8	26.6	10.1	10.6	13.3	13.5			10.4		21	20	23.7	32	15.1	13.9	15	17			11.1	8.4	25.3	22.5	26.2	37.7	15	15.5
Barbing	1380	20.5			5.8	11.2	5.8	10.3	20.5	18.9	24	25.6	9.6	10.4	16.3	15.2			10.3	6.6	23.6	22.8	27.5	32.7	14	14.1	16.2	17.4			13.2	13.7	26.5	24.5	30.6	36.7	12.5	12.9
Barbing	1285								18.5	18	22.8	25	10.1	10.3	16	16			9.6	10.3	21.4	21.5	25.5	29.2	14.8	14.5	15.4	16.3		58.9	13.3	11.6	25	22.9	29.6	36.6	14.9	15.1
Barbing	1269	22.3		70.6	6.8	11.7	6.4	11.4	21.1	19.1	25	25.5	10.4	10.9	16.4	16.2		62.2	11.8	11.9	23.4	22.2	29.4	32	15.2	15.5	16.1	17.4			12.5	11.9	27.4	26.9		36	15.4	14.5
Barbing	1357	20.5		71.6	4.5	9.6	5.4	9.2	20.6	16.9	27.7	25.5	11.1	11.4	15.6	16.3			8.5	9.8	23.2	21.8	25.2	31.7	14.1	15	15.1	16.9					27.5	25.8	27.8	38.6	14.1	14.6
Barbing	1284			68.5																	21.7	21.2	26	32.1	13.3	14.2	16.4	19.7		48.5	13.8	12.6	24.3	24.1	26.9	38.4	14.1	13.5
Barbing	1269	21			5	6.9	5.1	6.4	18.8	17.8	25	27	11.4									22.1	26.3	36.6								28.1	27.3	32.8	41.6	15.4	15.2
Barbing	1350	20.8			6.2		5.8	10.2	20.9	18.7	28.3	24.8	11.2	11.2	14.4	14.7		64.8	9.7	10.9	24.5	23.5	27.6	34.1	15.9							26.5				39.4	15.6	14.5
Barbing	1397	18.4	27.9	64.8	4.8	7.8	4.8	7	20.4	17.8	19.4	23.8	9.7	9.9	15.4	15.1	18.4	77.2	10.7	10.6	16.4		24.4	25.2	10.5	10.2	13.4	16	24.3	59.6	8.7	7.8	26.8	25.8	28.5	34.3	13.8	13.7
Winterthur	138	22.1		73.8	6.7	12.1	6.5	11.3	19.6	18.7	23.1	25.4	11.6	10.8	16.5	17		57.2	12.1	10.9	26	26.1		33.9	16.2	15.3	18	16.5		57.9	11.7	11.5	28.5	27.9	27	36.4	15.9	15.8
Chur	525																														26	26.8		35.2	13.5	15
Chur	524																														23.8	21.3	25.5	35.3	13.6	12.4
Chur	444	21	31.9	71.2	5.1	8.4	4.5	8.6	19.1	19	25.6	25.3	9.8	9.7	13.9	16.4	25.6	58.2	12.7	12	23	22.8	28.6	28.8	13.9	15.1	13.6	15.9	25.8	54.9	10.3	11.9	26.2	27	28.6			
Chur	434	21.4		65.5	6.4	9.5	6.2	9.3	15.7	16.7	21.5	24.1		12.5		16.6					18.9	21	24.7	28.4									32	29.4	27.4			12
Chur	408						6.4		18.5	17.9	24	24.1	9.7	9.2	15																					
Chur	527	21.6	32.5	76.1	5.8	9	5.9	9.3	19.1	16.7	24.3	26.2	10.9	9.8	15.3	14.1		66.2	10.1	10.5	21.3	18.8	29	30.6	12.5	13.4	15.9	16.5	25.5	65.4	10.6	10.2	26.1	25	26.2	36.9	15.3	14.9
Chur	477	21.2			5.9	9	6	8.8	19.4	16.8	22	26.3	10	10.8	16	17.1		58.2	13.8	13.1	23	22	26	32.1	14	14.1	15.2	17.3	21.9	51.4	12.4	10.5	27	26.5	26.8	37.6	16.7	15.9
Winterthur	15	25.2	29.1	75.7	5.6	10.2	6.9	9.6																													
Winterthur	13	22.2	23		6.2	10.4	5.6	9.6	17.6	15.6	21.7	25.5	10.2	10.8	15.5	15.8			11	10.7	19.5	18.3	26.8	31	13.8	13.4	13.3	15.2	19.5		10.6	10	23.6	22.1	26.5	37.1	13.7	14.6
Winterthur	115	20.4		73.7	6.8	10.8	6.5	10.5	20.6	19.1	24.8	25.4	10.3	10.4	16.3	15.3	14.9	60.5	11.1	14.7	22.7	21.8	30.3	30.4	14.4	14	16	17.5	23.7	58.1	13.3	13.6	28.6	27.3	31.4	33.6	14.2	15.3
Winterthur	73	23.1		76.4	7.1	10.3	7.3	9.4	18.4	17.8	20.2	25.8	9.8	10.3	15.3	17.5	16.1	66.8	10.8	11.1	22.4	22.4	24.5	32.5	13.8	13.8	16.6	17.5	25.7	57.2	9.4	11.4	28.5	24.5	24.6	35.8	12.7	13.3
Winterthur	9	19.1	31.5	66.3	6	10.1	6.1	8.5	17	15.5	18.1	24.9	9.8	9.6	16.5	16		55.9	13.8	11.4	19.8	19.4	24.8	30.7	12.9	12.5	15.7	17.4			11.6	11.3	23.6	20.8	26.2	36.2	12.8	12
Winterthur	29						7.1		18.8	15.9	24.5	24.2	10.7	10.4	16.4	17.4			13.5		21.2	18.1	27.2	32.6	13.2	13	15.9	18.6		53.6	13.2	10.5	25.9	23.9	27.9	35.8	13.5	13.6
Winterthur	93	20.5		71.6	6.2	10.3	6.3	10.4													22.3	22.2	26.5	31.6	13.1	13.9	17.8	17.6	24.6		13.2	12.6	22.3	22.2	26.5	31.6	13	12.2
Winterthur	26	21	26.6	70.6	6.6	9.9	6.7	10.3	19.2	18	22.3	23.6	6.5	10	15.8	17.4		65.6	11.6	13.2	19.6	20.5	26.8	29.1	14.6	13.7	13.5	15.8		54.7	11.2	9	25.3	24.4	27.7	34.5	14.7	14.4
Winterthur	87	20.6		78			5.9	8.8	16.2	16.9	23.6	24.1	11.3	10.6	14.7	15.3		60.2	10.5	12	21.5	20.6	24.9	27.2	13.5	14.2	15.7	18.3	25.7	56.8	14.1	13.3	23.7	20.9	26.3	32.2	13.4	13.4
Winterthur	52	24.6	26.9		6.7	9.8	6.8	10.6	18.9	16.1	21.6	22.8	10.4	10.5	16.5	17.1	16.2	63.2	13.3	12.2	21.8	21.2	27.1	31.1	13.6	13.3	18.2	19.8			13.5	12.3	25.1	23.1	30.9	37.5		10.7
Winterthur	8	25.6	28.5	71.4	7.2	11	7.2	11.2	20.6	18.4	25.5	25.5	9.6	9.6	16.9	17.3		62.4	11.9		24.6	22.3	25.9	31	14	15				50.8	15.8	14.5						
Winterthur	21	20.2	26.8	67.9	7.1	12.3	6.6	11.4	19.3	18.2	22.5	22.8	9.9	9.1	16	16.7					19.6	20.2	23.1	29.4	12.6	12.2	14.9	16.7		49.6	11.7	10.7	22.4	22.2	26	30.6	13.2	14.1
St.Johann	282	23.1	24.2	71.9	6	8.8	6	10.2	17.5	16.8	20.6	23.2	8.8	9.5	15.2	15.3		59	13.6	9.9													24.6	22.4	24.4	31.9	13.2	13.1
St.Johann	244	22.4		63.5	5.9	9.4	5.8	10.2	17.9	16.8	20.6	22.2	8.7	8.8	15.1	17.5		54.7	12	12.9													27	24.9	27.1	36.1	13.3	14.5
St.Johann	300	22.8		74.8	6.1	8.2	5.8	8.5	19.8	17.5	23.5	23.8	10.2	10.6	17.1	17.5	16.9	61.2	11.4	8.5	22.7	21.8	25.7	28.3	14.1	14.7	16.6	18.4	22.6	59.6	12.2	12.1	27	24.9	27.1	36.1	13.3	14.5
St.Johann	1404	20.2		76.6	4.4	8.8	4.5	6.3	20.8	18.2	23.1	24	8.6	8.6	13.9	16.5		59.2	12.3	6.8	21.8			29.2	12.3	12.3	13.8	15.2		58.3	13.2	10.9	28.3	26.2	29.4	37.8	13.6	15.6
St.Johann	493	20.7	23.6	71.3	6.5	11.6	6.2	11.4	18.9	15.8	22.8	24.2	9.6	10.4	17.3	16.3	18.3	58.8	12.9	11.6	21.4	21.2	26.1	31.9	13.6	13.9	17.9	17.2	21.1	55.2	13.3	15.2	26.4	21.7	30.2	34	14.7	15.1
St.Johann	317	24.9		73.8	7.1	9	6.7	10.3	18.6	17.7	24.1	24.3	10.3	11	17.4	20.8		62.6	16.9	12.2	23.5	19.7		30	14.2	14.7	16.7	18.7			12.2	11.8							
St.Johann	1104	25.1			5.4	9.7	6.4	9.5	18.2	16.8	26.8	29.6	11.4	11.2	14.9	18.1		67.2	10.5	10.6	22	20.6		36.5	14.6	14.1	17.5	18.8		59	13	12.1	22.6		40.3	14.1	14.3
St.Johann	41	20.2	31.8	77.7	6.6	12.1	7.1	11.9	18.8	18.7	27.5	27.6	10.2	10.3	16.8	16.1		66.5	10.5	9.3	21.5	20.4	30.9	34.9	13.5	13.2	16.2	17.8		66.4	13.5	12.9	24.9	24	34.8	41.5	12.8	13.8
St.Johann	56	20.9		66	5	8.1	6.1		18.5	18.2	23.8	24.4	9.3	10		15.1					20.6	20.7	26.8	32.2	13.1			16.7										
St.Johann	60	18.9		68	6	10.4	5.9	10.4	18.5	17.3	21.7	23.9	9.6	9.6	15.2	14.1		57.7	12.1	12.2	21.3	20.6	28.8	29.1	12.4	11.9	13.5	14.8		51.3	11.9	11.6	25.8	25.2	26.4	32.8	12.5	13
St.Johann	16	20.8		68.7	7.4	10	7.6	10.6	18.1	15.8	20.8	20.2	11.1	11.5	15.3	15.8					20.5	21.1	25.9	26.1						57.7	11.3	12.8	24	22.9	25	31.5		11.1
St.Johann	276	22.7		71.7	6.5	11.2	7.5	10.5	20.5	19.2	21.8	23.2	9.8	10.1	17.4	15		54.2	11.8	10.8	22.9	21.8	25.9	27.7	12.4	13	15.9	15.8		52.3	12.5	12.1	27.6	27	25.1	33.6	14.7	15.1
St.Johann	266	22.4	26.6	77.5	7	11.2	5.9	10.6	19.2	15.8	25.6	23.9	10.2	10.3	16.4	17.6	7.8	58.2	8.7	8.5	20.3	20.8	26.4	26.9	12.4	11.9	16.9	18.5	20.2	59.4	13.2	13.1	28.7	24.2	25.1	33.9	14.2	14.3
St.Johann	1320	20.3		67.8	6.3	9	5.5	6.8	20.4	18.6	21.1	24.7	10.3	9.6	15.3	13.8	15.7	55.8	12.6	10.2	23	21.6	25	31.6	14.6	13.6	15.1	15.3		55.6	12.7	12.5				34.9	13.3	12.8
St.Johann	1710	20.8	30.2	77	5.2	8.2	5.9	9.1	22			28.6	12.4	11.5	16.7	18.6		61.5	13.8	11.9	24.2	23.4	32.8	35.2	13.2	15.3	15.3	20.6	32.8	52.4	10	11.1	26.8	27.3	28.5	41	14.2	15.1
St.Johann	632								19	17.8	24.2	25.8	11	10.7	15.4	15.1	9.8	54.9	13.1	12	22.9	22.1	25.8	30.6	11.2	13.4	15.6	15.4		54.8	13.1	12.3	26.1	26.3	27.1	36.3	12.1	12.8
St.Johann	527																				19.6	22.2	25.1	30.3	13.2	12.5	17.2	17.4	20.8	57.3	11.5	12.8	23.5	23	27.2	34.9	12.2	12.8
"Geneva"	6	22.5			6.5	11	6.8	11.3		17.4	21.3	23	9.9	10.4	18	17.1				12.5	20	20.1	25.1	30.8	14.3	13.7	17.6	18.6			14.9	14	24.2	22.2	27.7	35.1	13.8	14.1
"Geneva"	15	23.5		74	7.6	12.1	7.5	10.1		16.8	26	24.4	9.8	12.2	17.8	18.8			13	11.5	21.4	16.4	30.8	30.8	14.6	15.3	18.7	20.1		57	13.2	13.4	27.3	24.6	31.6	36.3	14.6	14.3
"Geneva"	4	21.7	29.8	70.9	6.5	11.5	7.5	12.7	21.7	18	29.5	25.1									23.5	21.6	22.9	31.5	16.6	16.1	15.8	17.7			11.4		28.6	26.9	29.6	39.3	15.6	15.6
"Geneva"	2	23.7	32.2	74.6	6.7	11.2	6.4	12.6	20	16.1	24.2	24.6	11	11.1	16.8	18	25.4	70.1	11.4	12.3	21.8	21.1	27.5	32	15.6	14.2	19	19.1	30.3	67.8	14.7	14.9	28.5	23.7	29.4	37.7	15.1	14.8
"Geneva"	16	25			7.6	10.6	8.1	12.4	22.7	19.6	23.8	25.5	11.3	11.2	16.8	17.8	13.6	62.5	13.5	12.8	24.2	24.5	27.7	30.7	14.3	14.3	16.8	19.3		61	13	11.1	29.2	26.8	30.8	38.8	14.5	14.1
"Geneva"	17	22.1	28.6	77.6	7.2	11.1	7.8	10.4	19.9	17.8	25.6	23	10.8	11.4	15.5	15.4	19.7	61.6	12.4	13.2	22.6	23.2	29.9	30.7	15.6	17.4	16.7	17.3	26.3	63.8	13.5	13.3	27.2	25.5	28.8	35.7	17.2	16.4
"Geneva"	11	21.5	27.3	74	7.8	11.6	7.6	11.8	19.1	17.9	25.9	24.8	10.5	10.6	16.4	17.2	16.2	65.8	13	12.5	22.1	21.5	30.8	30.9	14.3	14.5	15.4	17.1	26.6	61.2	11	12.6	27.9	27.2	29.4	35.7	19	15.3
"Geneva"	5	21.9		71.4	5.8	8.9	6	8.8	21.6	18.5	23.3	26.6	12.8	13.2	15.3	16.3		61.3	13.5	12.3		23.3	27.7	33.7	18.7	17.8	15.4	18		58.2	11.5	11.9	27	28.6	29.2	38.7	15.7	16
"Geneva"	7	20.4	30.8	70.9	6.3	12.2	7.8	11.3	20	16.3	21.8	23	11.9	10.7	15.7	15.7	25.3	59.4	15.7	13.2	20.7	20.6	25.8	30	13.8	13.4	15.8	17	29.6		14	12.6	25.5	24.9	26.8	36.8	14.1	14.8
"Geneva"	16	24	33.5	76.9	7.8	9.5	7.1	10.8	22.2	19.6	24.2	24.4	13.6	14.2	15.3	17.2	18	62.6	11.6	12.6	21.8	25.6	28.5	30.2	17.8	17.6	17.6	18	25.4	64.1	12.4	11.9	28.7	25.1	27.8	33.2	17.2	17.8
"Geneva"	1	23.2	28.6	75	8.4	11.8	8.2	11.5													24.8	20.4	28.6	30.6	16	16.1	17.8	20	24.6		12.2	14.1	30.6				35.9	14.8	15
"Geneva"	4	22.2	31.3	73.5	6.5		7.3	11.1	19.5	16.6	21.6	23.5	11.4	11.8	16.5	18.5		64.6	7.7	8.3	22.4	20.2	26.1	30.9	15	15.4	16.6	16.9	31.1		13.8	14.2	28.8	25.6	24	35.2	15	15.4
"Geneva"	10	24.8		68.2	7.6	11.5	7.3	10.3	20.8	18	21.6	27.3	10.9	11	15.6	20.6			14.8	14.9	24.3	23.8	29.1	34.6	15.5	15.4	17.3	21.4	27.3	56.6	14.3	12.8	28.6	28	32.5	37.5	15.8	15.5

Individual / Sample	Specimen number	L1M10	L1M11	L1SPL	L1TPW	L1IFlcr	L1IFlce	L1IFrcr	L1IFrce	LSM2	LSM1	LSME	LSM3	LSPH	LSPHV	LSM10	LSM11	LSSPL	LSTPW	LSIFlcr	LSIFlce	LSIFrcr	LSIFrce	FMM16	FMM7	HLM1	HCM7	FHM18	FLM1	FCM8	BWM2
																												43.2			
CroMagnon	2																											38.6	419	79	248
Teviec	1	16.5	21.9	22.4	71.5	7.5	11.4	7.4	10.6	20.7	21.6	35.1	42.4	12.4	10.8	14.6	23.2	20.7		6.2	8.2	5.8	7.6	35.9	31.8	289	50			76	
Valhingen	115									21.3	24.9	29.2	40.6														52				
Valhingen	93									24.5	27.4	31.5	45.7	13												298	60	42.9	402	75	
Valhingen	45	16.5	21.6	24.1		9.3	14.6	9.7	14.9	26.3																283	57	39.1	385	81	
Valhingen	87																											44.8		80	
Valhingen	14									27	22.6	31	47.6		11.2													43.5			
Wanderslaeben	2241																											40.7		85	
Wanderslaeben	2124	17.1	20.8	23.5			12.6		12.7	22.5	26.2	29	38.2	14.2	13.6	18	24.1	19.5	40	5.5	10.7	6.1	9.6			284	55	39.9	399	75	
Wanderslaeben	2299	15.3	21.8	28.8	65.6	6.9	10.4	6.6	10.1																		59	40.3		83	
Wanderslaeben	2243			18.6						20.6	21.7	33.1	42.8	11.7	15.1	13.8	26.5	17.9	73.2	5.6	11.6	5.9	12			285	56	40.3		75	
Wanderslaeben	2230	16.7	20.8		44.2	7	10.7		11.2	22.5	25.2	32.3	41.8	14.5	14	11.9	24.2	21.8	41.5	5	7.6	4.8	6.8			282	57	39.6	397	75	
Wanderslaeben	2214	18.3	22.9		71		12.4		11.5				40.5	14.9	15.8				57.8									42.6	394	85	
Wanderslaeben	2250	19.6	23.5	26.4	69.3	10.6	15.3	11.3	13.3	20.7	25.7	29.2	44.5	12.6	14.6	16.9	27.3	19.8	67.2	5.5	11.3	7.3	11.8			299	57	38.2	421	69	
Wanderslaeben	2200									23.7	24.8	32.3	43.7	12.4	11.9	16.3	23.2			5.1	9.1	5.3	9.3					42.6			
Wanderslaeben	2207																											40.7		85	
Wanderslaeben	2145	16.5	19.9				12.3		10.1	21.6	24.5	28	38.1							5.5	10.8	6.1	10.4			267	51	36.5	388	69	
Wanderslaeben	2295																										55	40.8			
Wanderslaeben	2300									26	25.5	33.6	44.1	11.9	12.8	15.1	22.4			5.7	8.1	5.7	8.7					42.2			
Wanderslaeben	2293																							34.9		285	61	40.2	397	76	
Wanderslaeben	2294	17.6	21.9		64.2	8.9	9.1	8.6	10.8	21.4	24.4	29.4	47.5	10.6	12.4	15.9	24.3		55.8							287	59	41.3	398	76	
Wanderslaeben	2283	16.8	19.6	25.7	62.4	6.9	10.9	7.9	11.6	26.3	30	31.7	44.3	12.9	13.1	15.3	21.4			4.5	6.6	5.3	8.5			285	60	39.8	397	79	245
Wanderslaeben	2137	18.1	23.6	24.8	49.4					24	27.5	30.4	47.5	11.5	10.6	18.6	25.1	20.7	78.5	6.9	12.9	8	12.4			286	62	39.7	407	84	234
Wanderslaeben	2135									25.9	26.9	36.3	43.9	14.8	15.4		23.5			6.1	9.6	5.7	8					43.2			
Wanderslaeben	2155	17.5	23.6		63.6	7.9	12.6	7.8	11.8	22.3	26.6	33.1	48.5	15.1	14.1	14.6	24.5			6.5	10.5	6.5	10.3			282	66	41.6	402	75	260
Wanderslaeben	2174	15.4	19.6		59.4	8.9	11.8	9.8	11.3	22	25	28.2	42.2	15.5	15.5	13.5	19.6			5.4	9.8	6	8			280	55	36.5	381	75	
Wanderslaeben	2112	16.8	22.2	25	64	8	11.7	8.4	12.1	23.7	30.5	33.5	44.2	16	17.8	23	27.8	20.5	67.5	5.8	11.2	5.5	11.6			290	58	42.3	416	79	267
Wanderslaeben	2225	18.5	23.8	23.8	66.8	9	13.1	8.3	12.6	22.5	29	34.5	43.2	14.4	14.7	16.7	26.2	24.2	81.3	6.1	11.9	5.8	10.9			283	55	39.2	392	79	238
Wanderslaeben	2189	18.9	25			8.6	14.8	9.8	15.2	25.6	30.6		49.4	14.1	19				81.2	5.5	10.5	7				281	55	41.7	435	75	255
Wanderslaeben	2187		23.5	25.1							25.8	25.6	46.9	13.5	14.4	16.8	27.4			5.3	11	6.2	13.3			312	91	44.6	460	86	
Wanderslaeben	2234	16.8	19.8			10.8	13.2	9.6	13.5	21.4	23.9	31.8	44.7	11.5	12.1		26			7	10.8		8.3					40.1			
Wanderslaeben	2114	18.1	21.5			8.5	12.1	8.2	13.7			33.9	52.1		16		26				5.1		6.3			276	60	43.2	387	79	
Wanderslaeben	2239	17.2	22.2			8.3	12.6	8.4	12.6	26	25.8	29	41.5	12.5	12.4	16.3	23.5			6.8	9.8	6.2	9.7			272	56	38.7	386	79	
Hoeldic	8																									285	55	39.7	418	83	244
Birametten	1		20.3							21.9	25.6	29.8	41.9	12.1	13.4		27.2			6.1	11.3			34.7		290	53	36.5		77	
Heinburg	21126	18.8	25	29.2		10	15	11.4	15.6	23.7	29.5	31.7	46.6	13.8	12.8	17.2	30.8	20.7	89.9	7.4	11.5	7	12.3		28.2	318	57	46.3	435	78	292
Heinburg	21059	16.2	21.4	28.1	64.2	6	13.7	9.8	12.9																	279	54	40.3	390	68	273
Heinburg	21076		23.2	19.5		9	10.3		13.2	25.8	31.8	33.1	45	12.2	13.2	17.8	24	23.9		5.2	9.8	6.1	10.9			314	57	41.5	430	72	
Heinburg	21086	16.2	20.9	27.2	57	8.5	11.7	8	12.2	23.8	27.1	31	47.5	14.9	15.2	17.2	24.9	27	85.5	6.4	12.6	6.9	11.4			301	58	43.2	408	76	247
Heinburg	21118	17.5	22.8		71		15.3	9.1	12.2	25.3	30.8	31.9	45.7	14	16.4	17.2	24.4	22.2		6.2	11.8	6.5	12			306	58	43.2	423	75	267
Heinburg	13055	18.8	22.3		59	8.3	10.8	8.3	11.9	18.8	26	29.6	43.8	13	12.6	17.5	26.6		81.2	6.4	11	5.6	12.2	33.2	25.9	296	58	38.8	406	71	242
Heinburg	9716	16.8	22.1			8.6	14.3	8.3	11	17.7	23.6	28.7	43.6	10.2	13	16.6	24.4			5.3	9.6	5.8	10.8	38.1	30.5		53	40.5	432	71	
Heinburg	13036	18.7	22.9			8.3	14.9	9	14		22.9	33.5	44.8	9.5	13.8	21.3	29.2			6.8	11.2	7.9	10.5	38.5	33.6	296	53	39.5	385	71	
Heinburg	21051	16.2	23.2		69	10.4	13.5		13.2	23.1	26.1	35.3	46.9	11.9	12.4		25.8		81.5	5.3	7.5	6.8	7	38.4	33	315	58	42.5	429	75	266
Heinburg	9881									25.8	24.9	31.5	42.9	13.1	14.3	12.3	19.9	24.5	81.2	5.9	6.4	5.6	7.8	31.9	25.2		68	41.2	386	75	243
Heinburg	21090	17.7	22.2	32.2		9	10.5	9.7	11.6	25.7	32.3	35.3	51		17.6	16	26.6	30.9	49.7	6		5.2	12.2			357	71	49.3	492	90	
Heinburg	9865	16.8	21.5	24.3		7.2	13.4	7.4	11.6	21.9	25.9	31	44.3	10.9	11.4	17	23	21.1		5.8	9.1	6	9.6				56	40.6	392	72	
Heinburg	9730	16.3	20.9	27.1		8.6	13.7	8.9	12.5	20.4	26	33.2	45.7	12.5	13.5	13.3	31	21.4	93.4	6.4	7.4	5.6	8.9				57	43.3		76	
Heinburg	21133	18.4	21.2			8.9	13.8	9.4	12.8	22.2	24.4	30.8	45.6	13.8	11.6	19.3	30.9			8	7	7	9.6			285	58	38.9	392	76	251
Heinburg	13117	16.8	24.3	31.3		9.8	13.7	9	13.2	23.1	27.2	31.6	48.7	12	13.5	16.1	30.9	26.9	87.4	6.1	11	6.9	12.3	38.4	32.2	296		41.6	397		
Heinburg	13083	15.1	18.2	24		8.5	12.2		11.8	25.5	26.8	35.9	44.1	13.7	12.6	13.5	22.9	25		4.6	8.3	5.3	7.8		27.6	301		41	432		
Heinburg	9729	18.4	23.1				14.6		14.9	22.8	27.1	31.4	46.5	11.2	11.9	13.1	27.1	20.6		7.3	10.6	6.1	8.8	35	31.3	288	56	43.5	406	68	
Heinburg	12199	15.9	21.3		55.6	9.7	12	8.9	12.2		25.4	23.6	37.3	10	11.4		22.4		74.2	4.8	8.6	5.7	7.8	32.9	29	256	48	37.6	407	65	246
Heinburg	12137	17.3	22.7	27.2		9.8	13	11.3	14.3	23.2	23.2	34.7	47.6	11	13.4	16.2	25.6	26.5	47.2	8.3	9.8	5.9	10.6	34.2	32	306	60	42.5	404	75	288
Heinburg	9707	16.8	20.9			8.5	13.2	9.1	13.3	24.9	26.3	32.8	45	17.7	15.7	15.7	22.8	24.2	86.8	6.6	9.5	6.2	10.2			279	54	42.4	402	71	280
Heinburg	21111	15.6	21.1		64	9.3	12.9	9.6	13.1	22.6	29.7	30.7	41.9	14.8	14.7	17.5	25.9	18.9	86.8	6.2	10	6.5	11.1	32.2	27	283	55	40.2	420	67	270
Heinburg	21095	15.5	19.4	28.5	58.4	7.8	12.5	10.2	12.6	25.9	27.6	34	46.6	16	13	15.5	25.8	25.2	87.5	6.1	7.9	6.3	9.3	37.9	25	289	59	40		76	275
Heinburg	21067	15.6	23			9.5	14.8			23.6	30.2	31.5	44	11.2	10.3		24.7		76.8			7.3	13.8			291	56	43.2	450	79	
Straubing	531									24.1	27.7	27.8	48.7	11.7	13.1	16.8	26.8			6.5	8.4	6.4	9.6	36	28.8	312	53	42	426	79	
Straubing	780	15.5	21.1	24.6		7.3	12.2	7.3	11.7	26.3				14	12.6	16.2	22.3	26.9	49.3	6.5	7.2	6.2	9			342	53	45.4		81	290
Straubing	415	16.3	21.7		76.2	9.2	12.8	8.3	12.4	22.4	28.9	31.1	45.3	12.2	14.9	19.6	26.2	23.2	44.8	5.9	10.4	6.6	9.6			313	53	46.8	438	80	286
Straubing	288	20.3	25.6				15.2		15	19.4	24.6	28.9	42	11.3	12.8	20.3	30.5	26.1		6.4	10.4	6.8	9	37	28.4		58	38.8		90	
Straubing	741									25.3		29.6	44.4	13.2	12.3	16.2	22.9	25.2		7.1	12.3	6.4	11.4	35.8	28.2		59	43		85	290
Straubing	734	16.5	24									25.6	50.5			17.9	33.2			7.7		8.3					54	42.5	412	77	
Straubing	394	15	19.9	26.2			12.2	7.3	10.9	24	26.8	31.8	43	12.8	15.3	16.2	24.6	19.6	68.4	5.2	9.1	5.8	9.5			306	57	41.1	438	84	
Straubing	725	18.7	24.7			9	14.3	9.3	14.8	24.6	22		54.8	14.6	12.8	18.8	28.9			6.6	13.2	7.1	11.8			308	54	45.1		78	
Straubing	810	18	24.8			10.6	15.3		15.5	20.5	23.6	31.4	46.5	9.7	11.6	18.6	28.1			6.1	12.1	9.2	13.8			304	56	44.7	442	75	
Straubing	744	17.6	24.1			8.5	12.8	9.2	13.8	23.6	22.8	30.8	43.7	15.6	15	14.3	28.4			7.5	10.8	6.9	11.8			274	52	43.2	416	82	
Straubing	462	17.6	24.2			8.9	13.8	9	14	20.9	25.1	31.9	40.2	10.6	11.2	16.9	25.9	23.1	75.8	7.2	13	4.9	11.5			280	55	42.2	395	75	290
Straubing	351	21.1	27.1	24.2		10.6	12.9		13.5	24.2	30	30.7	44.1	10.2	12.2	22.3	29.4	18.5		8.5	12.2	5.8	12.6			335	58	42.2	466	85	
Straubing	474		21.3							21.5	21.6	33.8	46.4			14.3											64	42		83	
Straubing	614		20.4					8.5																34.8	28.2	298	59	44.5	435	87	303
Straubing	811	17.3	22.5			8.5	12	7.6	12.4	22.4			50.2	11.1	14.5	16.7	24.1		78.3	6.1	11.2	5.3	11.8			313	66	44.6	406	80	
Straubing	624	16.8	19.9				13.4	9.1	14.2	26.4	29.2	32.5	44.1	13.5	14.2	15.2	21.2			5.6	9.6	5.8	10.6			318	58	43	451	79	265
Straubing	305	18.7	25.2	32.8	62	10.2	14.7	9.5	14.3	22.7	24.2	29.5	42	12.8	13.1	17.7	29.1		41.4	7.5	14.1	5.5	13.9	36	31.6	308	56	41.6	445	83	266
Straubing	279	15.9	22.1	24.7	55.8	9.4	13.5	8.3	13.2	23.6	25.5	26.6	41.9	12.2	12.8	15.6	24.5	25.2	80.4	7.1	10.5	5.8	11.2		26.2		56	42.5	437	76	243
Straubing	792		24.8			8.5				20.7	25.5	26.4	40.3	8.8	9.5	15.7	24	21		7.3	11	5.5	10.3			282	50	39.2	403	73	
Straubing	468	17.7	22.9	21.5		10.2	13.3	10.8	14.2	22.5	24.6	30.6	42.2	10.5	9.8	15.5	26.9	17.7	73	6	11.1	5.8	11.5			301	54	41.5	454	78	267
Straubing	481	16	23.1			7.2	10.2	7.4	10.1																	317	58	44.5	448	85	
Straubing	601	15.2	21.7	27.3		8.9	12.5	8.6	14.1	23.4	24.5	30.7	42.5	13	13.2	19	26.1			5.6	10.4	6.2	8.6				60	41.2		75	
Straubing	786	17	21.4		61.2	7.8	12.2	8.9	11.7	21.8	24.2	31.6	43.6	12.5	12.4	15.8	26.7		64.8	5.1	11.5	6.3	11.2					41.9	402	73	258
Straubing	795																											45.1	476	85	
Straubing	377	17.8	22.6			9.6	13	9.1	13	22.8	25.5	38.2	50.5	12.2	12.5												55	43.4	462	95	
Straubing	248	20.5	23.9	14.8		10.9	14.2	10.2	14.4																	345	54	42.6	474	78	
Straubing	484	15.4	20.4	24.8	61.1	7.8	11.2	8.2	11.2	25.2		30.2	44	12.5	12.1	17.8	25.7			6.9	11.3	5.6	11.3			301	58	43.3	435	78	
Straubing	425	16.7	22.1			9.3	12	9.7	12.4	19.5	25.4	24.1	35	9.8	12.2	19	25.8	19.5	81.1	5	11.1	7.2	11.8			290	55	38	386	75	

Individual / Sample	Specimen number	L1M10	L1M11	L1SPL	L1TPW	L1IFlcr	L1IFlca	L1IFcr	L1IFca	LSM2	LSM1	LSM6	LSM9	LSPHI	LSPH	LSM10	LSM11	LSSPL	LSTPW	LSIFlcr	LSIFlca	LSIFcr	LSIFca	FMM16	FMM7	HLM1	HCM7	FHM16	FLM1	FCM8	BWM2
Straubing	284	16	21.9			9.6	10.4	10.1	11.8	21.2	25.6	29.7	48	12.1	12.2	15.2	24.1	22.2	76.2	6.3	11.2	5.8	11.8	36.2	29.5		56	42	406	75	
Straubing	618		21.8					9.5		27	21.5	32.6	45.1	14	13.2	15.9	25.0			5.5	12.5	6.2	12.2			322	60		442	98	258
Straubing	716									27.8	32.6	32.6	51.2	13.7	14		31.3										60	47.6		83	
Straubing	299	19.6	24.7	23		11.8	16	11.4	15.1	24.2	25.2	28.2	47			12.4	32			6.8	7.2	6.5	6				59	43.1	425	82	
Straubing	778	16.6	24.6			11.9	14.2	10.6	13.8															34.6	29.6		60	41.3	403	72	
Straubing	401	18.8	22	29.3	66.4	9.7	13.9	9.3	12.4	24	24.1	32.2	41.8	13.4	13.3	14.8	22.5	33.8		6.7	9.4	6.5	9.3			328	59	47.3	462	83	
Straubing	369	17.8	20.8			10	13.8	10.6	12.8	24.8	27.5	33.6	43.6		12							6	11.8				54	43.2	454	75	
Straubing	627	17.5	23.8	27.6	65.9	9.7	12.5	8.7	12.2	24.1	28.8	33.6	42.6	13.8	13.5	13.8	27.5	24.2	87	7.1	9.9	7.9	12	41.4	32.1	292	54	43.2	419	80	
Straubing	774	17.1	20.7			8.3	11.4	6.6	11.3	24.8	25.8	30.9	44.5	11.7	12.8	16.5	27.5			5.5	9.9	4.9	10.2			286	55	43.2	409	75	255
Straubing	686	17	21.5	25.7	68	8.4	12.7	8.6	12	25.3	28.8	33	41.9	12.1	13.1	15.4	23.5	22.3	80.8	5.8	9.3	6.4	9	36.4		294	53	43.2	442	79	258
Straubing	804	16.1	19.7			8.5	12.3	9.3	11.6	22.1	27.4	31	40.6	11.5	12	12.7	22.8		87.6	7	7.6	6.5	8.6			294	54	38.5	395	79	258
Straubing	711	16.9	22.5	22.4	61	9	13	10.1	12.4	24.2	26.9	29.2	44.9	13	13	15.1	28	23.8		8	12.6	7.5	11				58	45.5	447	86	280
Straubing	643		23.3							23.6	26.6	32.2	48.1	13.7	13.7	17	25.8			6.8	10.3	8.1	10.6				58	46.8	456	85	
Straubing	268	16.1	22.8			7.6	12.2	6.3	12.3	24.6	27.1	32.2	42.4	12.9	12.9	16.4	24.4			7.6	9.8	5.9	10.6			311	57	45.1	456	82	270
Straubing	504	16.2	21.3		73	9	12.4	8.8	12.8	24.1	24.7	32.2	41	14.6	15.8	19.3	29.5		85.8	6.3	10.6	6.2	9.5	38.3	29.4		57	42.1		78	
Straubing	576	20.5	23.4			9.3		8.1		23	30.9									8.2	11.3					317	57	42.1		78	
Aesch	40									25.3	30.7	32	51.8	13.6	15.8		24.2			5.2		6.1					54	46.8	458	90	
Aesch	15		20.7				11.9																				62	47.3	436	90	275
Aesch	18	18.9	24.1			7.8		7.7	13.6	25.6	30.7	31.8	49.5	17.1	18.6		29.3			5.8		8.2	11	39.7	32	351	61	47.5	466	89	
Aesch	5																											46.8	431	92	
Aesch	61	18	24.2			8.2		7.4	13	23.7	28.3	32.8	39.4	14.3	15.7	15.9	30.2			4.9	8.5	5.3	9.8				59	46.8	459	88	
Aesch	61		18																							305	57	42.3	429	84	
Barbing	1388		22.6			7	12.6	7	13	24.3	30.9	34.5	49.6	16.2	14.1	18.8	26.5			5.6	10.4	5.1	9.9			305	56	43.1	441	79	
Barbing	1319	18.3	23.9		68.2	6.5	15.1	9	14.4	25	29.8	29.9	42.7	12.5	14.1	22.5	26.1	21.9	94.2	6.5	12.3	6.8	12.4			323	58	42.9		79	268
Barbing	1293	19	21.6	28.2	51.6	7.3	10	6.8	10	24.7	27.9	31.2	42	13.9	15.1	15.2	24.5			4.6	9.6	6.3	7.6			296	55	43.7	410	79	275
Barbing	1356	18.3	21.5			8.4	12.4	8.6	13.1	24.5	29.5	32.4	46.3	13.9	15.9	14.2	26.9		97.2	5.7	11.5	6.2	10.5			314	55	43.7	442	75	270
Barbing	1380	16.3	21.5			8.4	12.4	8.6	13.1	22.2	25.5	32.7	42.8	13.6	15.2	18.5	27.2		84.5	5	9.8	4.8	8.9			274	55	42.6	387	72	266
Barbing	1285	17.5	22.2		71.9	8.5	12.1	7.3	12.4	27	26.8		46.6	17.2	17.1	15.8	27.6		49.6	5.9	11.8	8.7	11			321	55	44.6	468	79	
Barbing	1298	18.5	22.5	29.7		8.5	14.8	7.8	14	24.5	26.6	25.6	45.4	13.2	14.2	15.4	26.4		86.2	4.3	9.7	4.9	9.5			292	59	44.1		81	
Barbing	1357	17.4	23.2							24	24.9	32.9	48.8	13.5	13.5	19.1	29.5			4.2	10.8	5.1	10.5			305	58	44.2		79	
Barbing	1284	19.9	25.9	21.9	66.6	8.1	14.6	8.2	14.1	25.3	31.2	36.8	50.5	16.5	15.2	14.5	24.3		84.1	4.7	7.8	4.3	7.5					44	438	85	279
Barbing	1258	17.3	24.5			9.5	12.5	8.3	13.1	24.8	28.2	35.7	51													320	61	43.6	429	79	
Barbing	1350		24.1		35.2	9.4			11.8	22.6	26.2	27.5	41.7	11.9	14.2	15	23.9	28.8	87.3	5.2	10.2	4.5	9.6			284	49	39.7		70	255
Barbing	1397	16.5	22.4	20.6	62.4	6.3		6.6	11.2	25.3	32	30.3	41.3	15	14.7	20.6	26.1		87.8	6.3	13.1	7.3	12.2			295	58	43.2	427	77	268
Winterthur	138	20.6	22.9		62.1	8.6	14.9	9.6	14.8	24	31.1	32.6	42.8	12.3	12.5	19	25.6		45.8	5.5	12.2	5.4	12.3				66	44.9	442	82	274
Chur	525		23.6		77.4	8.6		8.4		24.5	25.2	31.5	42.1	8.6	11.2	15.6	25	23.6	80.1	5.4	8.7	6	9.2			273	52		378	76	265
Chur	524	18	23.9		55.6	7.9	11.9	8.4	11.5	20.9			39.1	9	13.5				64	5.8						292	56	40.5	409	80	
Chur	444									19	23.7	29	41.8	13.7	12.6		25.9		71.5	5.1	9.1	5.9				261	52				
Chur	434																										51				
Chur	409																									294	63	44	417	80	
Chur	527		21.9			8.1		7.5		23	27.5	32.6	43	11.6	12.1					5.5				34.1	28.6	292	55	41	382	72	
Chur	477	16.8	21.6	23.4		7.6	11.4	8.1	10.9	22.6	27.2	34.3	46.6	13.2						5.5	11.4						58	41.2	437	82	
Winterthur	15																							35.1	29.5		59	41	401	85	
Winterthur	13	16.2	21		64.3	8	12.1	9	11.5																	317	62	45.8	440	81	273
Winterthur	115	17.5	22.2	26.5	67.4	8.8	14.1	9.1	14.1	24.9	29.2	31.9	44	16.4	15.3	17.5	26.9	27.1	86.3	7.2	12.7	6.7	13.5			314	55	45.2	447	78	288
Winterthur	73	20.4	22.3		64.2	9.5	14.2	6.8	14.3	23	28.4	29.6	42	13.7	14.2	17.4	24.2	25	87.6	6.6	9.2	6.3	8			314	56	38.5	388	77	275
Winterthur	9	17.6	22		65.6	9.4	13.8	9.4	13.9	20.6		28.2	41.8	10.4	15.9	19.8	23.2	25	84.6	7.2	11	7.7	11.3	40.1	31.5	281	61	43.4	411	85	
Winterthur	29	17.7	24.1			8.2		7.7	11.3	20.3	25.8	31	40.4	12.2	13.1	19.3	25.6			5.9	12.5	6.9	10.5			315	61	43.4	411	85	
Winterthur	93	18	20.5			7	12.8	8.2	13.4	19.5	23.9	29.3	38.9	12.7	13.5	14.6	25.3			5.3	10.4	5.5	9.1			286	49	41.2	410	74	255
Winterthur	26																							33.8	28.5						
Winterthur	87	16.3	19.1	29.1		6.2	11.8	6.8	10.9	22.2	26.9	31.1	42.9	11.8	17.3	15.8	23.1			5.8	10.5	5.5	5.8			315	56		446	83	290
Winterthur	52	18.7	23	28.1		9.3	14.8	9.2	14.3	24.2	27.4	29.1	37.9	10.9	13.2	17.5	21.9	30.1		5.6	8.5	5.4	8.4	33.1	30.1	298	55	40.9	403	82	285
Winterthur	8		23.9			7.5				22.9	30.1	33.7	43.2	11.8	12.5	17.7	26.9			6.8	9.8	7.1	10.6			303	60	45.4		81	
Winterthur	21									23.3	29.8		37.6	11	13.8	16.8	25.3	26.8	81	7	13	7.3	11.6	33.9	26.5	309	55	43.7	386	81	258
St. Johann	282	15.5	23.9			9.3	11.5	10	11.8		23.7	30.5	39.8	9.1	12.5	14.9	23.6			5.6	13.1	5.3	10.5			276	54	37.4	373	71	270
St. Johann	244	16.7	22.3		59	7.3	11.4	9	11.8	20.9	25.6	25	37.6	12.2	11.1	16.6	23.9		81.1	5.9	10.3	5.3	9.1			282	53	37.2	408	74	270
St. Johann	300	17.8	22		76.2	9.2	12.4	8.1	11.4	22.4	26.8	28.5	40.2	11.4	12.8	17	25.2	28.5	81.8	5.3	7.8	5.5	9.9	38.6	34.8	314	62	42.5	435	85	295
St. Johann	1404	17.2	21.6	29.5		7.9	12.6	7.9	13.3	25	29.1	30.1	43.7	10.2	11	15.6	23	32.8		6.1	11	5.3	11.4	38.9	28.3	310	57	43.6	436	85	299
St. Johann	493	17.4	24.6	25.5	76.1	9.8	12.4	8.7	12.4	22.9	25.3	31.9	46.1	15.4	12.7	17.6	31	21.6	85.9	7.2	12.7	7.2	12.2	39.4		299	55	45	432	82	318
St. Johann	317																							38.3	32.8	300	58	47.5		75	
St. Johann	1104	17.8	24.5		61.8	9.8	14	9.2	13.5	23.2	27		45.5	12.9	12.7	20.1	27.9		86.4	7.4	12	7.8	11.4			355	74	51.2	475	95	296
St. Johann	41	16.8	23.5		71.8	10.3	12.8	9.9	12.9	23.7	31.6	32.8	47.1	12	13.7	15.9	24	29.9	82.4	5.5	9.1	6.1	11.1		28.8	348	62	44.4		85	300
St. Johann	56																							32.9	30.8	312	61	43.2	435	85	
St. Johann	60	16	20.4		62.9	8.5	12.8	9.7	12.9	22.8	27.3	29.3	38.2	7.5	8.8	18.2	24.1		82.4	8.9	12.1	9.4	12.4	30.4	28.3	272	55		386		248
St. Johann	16	16.6	20	20		9	13.2	8.8	12.7	21.2	27.3	27.4	36.9	9.2	11.5	14.7	24.2	23.6	74.8	5.8	10.2	7.1	10.5			292	50	39.7	409	74	262
St. Johann	276	18.7	21			7	13.6	7.9	12.9	25.9	30.6	29.1	37.9	11.6	10.4	15.9	21.9		79.4	5.8	10.7	6.6	10.5	31.8	28.3	282	59	42.2	402	82	268
St. Johann	266	20.6	23.8	25.4	63.6	9.6	14.8	9.2	13.8	24.2	28.9	27.5	40.5	11.9	12.2		29.5	25		7.7	11.7	8.6	14.1	40.1	37.5	308	56	45.8	436	77	272
St. Johann	1320	16.7	21.3			10.2		9.2		22.9		25.6	39.1	10	11.2	16.3	24.2	23.6		5.5	11	6.1	9.4	31.9	31.4	286	45	39.4	456	91	
St. Johann	1710	19.1	27.5	33.8	77.1	7.2	10.3	8	11.9	24.5	30.2		43.1	15.8	16.1	20.6	30.8		88.8	7.6	10.5	8.3	12.1	34.4	28.6		58	45	436	80	287
St. Johann	632	19.2	22.2	30.4	64.9	9.4	14.1	8.8	13.8	21.3	28.8	30.9	42.2	13	12.6	16.5	28.1			6.3	10.1	7.3	9			305	56	43.6	412	78	275
St. Johann	527	17.8	22.6			6.7	13	7.2	11.8	23.9	28.3	28.2	39.3	13.2	11.7	19.2	22.1	25		6.9	12.8	7.2	13.2	33.8	31.8	266	53	41.6	385	74	270
"Geneva"	6	18.6	22.8			9	14.7	9.2	14.5	19.8	26	31.4	44.2	13.5	14	19.3	29.4	26.8		6.9	12.8	7.2	13.2	36.2	31.4	308	55	47.6	414	83	295
"Geneva"	15	20.4	27			10.9	15.2		16.7	24.4			49	16.5	14.3	20.9	28.6			8.9	13.1	8.2	11.5			321	62	45.2	432	85	270
"Geneva"	4	18.4	23.9		57.6	9.3	12.4	9.4	13.4	25.4	29.2	31.6	43.7	14	13.6	19.1	25			7.1	11	8.1	12.3			297	58	43.6	415	83	298
"Geneva"	2	19.8	24.4	32.4	70.2	10.4	14.8	11.8	14.4	22.4	28.1	28.8	44.5			16.9	28.5			8.8	12.6	8.7	15.1				56	44.4	422	76	
"Geneva"	19	20.1	23.6			10.8	14.8	12	14.9	23.5	28.5	33.6	45.3	14.1	14.7	16.5	24.8	31	81.6	6.5	11.5	6.6	10.4	34.3	34.6	292	58	45.8	453	87	300
"Geneva"	17	19.9	24.9		73	11.1	13.9	11.6	13.8															40.7	30.9	325	59	42.6	420	83	270
"Geneva"	11	19.2	22	28.5	65	10.6	14.8	10.3	13.9	26.3	30.6	30.3	45.8	14	16.6	20.5	30.7	19.5		7.8	10.7	9.8	8.7	36.8	30.9	288	58	43.6		86	288
"Geneva"	5	17.3	23.4		73.8	8.6	11.3	10.3	11.1	24.2	26.8	32.9	45.4	13.1	15.1	15.3	25.5	31.2	69.8	6.6	7.3	6.2	9.6	30.1	27	298	62	43.6		86	288
"Geneva"	7	17.9	21.3	33.2		10.2	14.6	9.8	14	21.9	28.5	30.5	40.2	14.4	14.9	19.4	27.8		100.1	8.3	14.8	8.9	12.9	37.4	31.2	309	54	40.9	422	81	270
"Geneva"	16	20	23.6	27.1		6.7	14.4	7.7	14.2	23	28.6	32.2	42.1	13	16.2	17.3	26.5		82.3	7.4	13.2	7.6	11.2			308	58	44.1	428	90	277
"Geneva"	1	21.6	24	30.2		11.9	16.4	11.6	15.8	27.3			44.6	12.1	15.1		27.4			7.6	11.9	8	13.1	40.4	33.1	331	58	45.8		86	
"Geneva"	4	18.3	22.1	33.2	71.6	8.5	14.6	10.5	14.1	25.8	26.8	30.8	43	12.6	12.6	16.6	25.3	28.1	92.6	6.6	11.2	6.3	10.5	33.2	28.8	306	60	42.8	431	83	278
"Geneva"	10	20.3	24.6	31.9		9.7	15	10.1	15	25.9	32.3	36	44.3	16.3	17.4	19.7	32.9			8.7	12.4	8.3	11.9	40.3	34.4	301	55	46.4	447	87	280

Males - Neolithic / Bronze Age

		AGEGROUP	C3M2	C3M1	C3M6	C3M9	C3PHL	C3PHR	C3M10	C3M11	C3SPL
N	Valid	36	24	24	24	23	22	20	20	21	6
Mean		1.53	13.70	13.33	15.65	20.43	7.31	6.98	14.61	23.07	16.03
Median		1.00	13.80	13.35	15.50	20.40	7.45	6.90	14.50	22.80	13.80
Mode		1.00	13.60[a]	13.20	14.90[a]	17.10[a]	7.50	5.80[a]	14.00	22.80	13.50
Std. Deviation		.70	.89	.97	1.87	1.96	1.11	1.01	1.52	1.33	4.08
Minimum		1.00	11.40	11.20	12.30	17.10	5.20	5.40	11.50	20.50	12.60
Maximum		3.00	15.20	15.70	18.70	24.00	8.90	8.80	18.60	25.30	21.60

		C3TPW	C3IFLCR	C3IFLCA	C3IFRCR	C3IFRCA	C7M2	C7M1	C7M6	C7M9	C7PHL
N	Valid	15	21	21	22	22	22	23	24	24	21
Mean		52.74	5.94	6.99	5.99	6.89	14.62	13.94	16.18	26.23	7.14
Median		52.20	5.90	6.80	5.75	6.70	14.80	13.80	16.15	26.55	6.90
Mode		45.40[a]	3.50[a]	6.20[a]	5.40[a]	6.20[a]	14.30	14.80	15.80	23.00[a]	6.20[a]
Std. Deviation		4.16	1.52	1.54	1.05	1.37	.90	.86	1.14	2.67	.99
Minimum		45.40	3.50	4.50	3.80	3.90	12.60	12.00	14.00	21.10	5.80
Maximum		60.20	9.10	10.30	8.30	8.90	16.20	15.20	19.20	30.90	9.30

		C7PHR	C7M10	C7M11	C7SPL	C7TPW	C7IFLCR	C7IFLCA	C7IFRCR	C7IFRCA	T1M2
N	Valid	22	22	22	15	4	22	22	22	22	24
Mean		7.14	14.58	24.00	29.74	53.48	5.95	9.09	6.25	8.96	17.02
Median		7.25	14.30	23.95	30.20	49.40	5.75	8.95	6.30	8.80	16.80
Mode		6.00	13.80	22.90[a]	31.50	47.00[a]	5.30	8.70	6.40	8.30[a]	16.80
Std. Deviation		.98	1.46	1.78	3.90	9.82	1.04	1.29	.96	1.46	1.22
Minimum		5.70	12.40	19.80	19.30	47.00	4.10	6.80	4.10	6.40	15.00
Maximum		8.80	17.90	26.90	35.40	68.10	8.00	11.20	8.10	12.00	19.80

		T1M1	T1M6	T1M9	T1PHL	T1PHR	T1M10	T1M11	T1SPL	T1TPW	T1IFLCR
N	Valid	23	22	23	22	22	23	23	19	15	21
Mean		15,88	16,70	28,69	9,87	9,30	14,84	21,43	30,83	75,31	6,06
Median		15,80	16,50	28,50	9,90	9,45	15,00	21,00	30,50	77,20	6,00
Mode		14,80[a]	15,80	29,50[a]	8,10[a]	8,30	15,60	19,40[a]	30,50[a]	75,00[a]	6,90
Std. Deviation		1,11	1,35	2,39	1,20	1,18	1,25	1,91	4,29	6,28	1,19
Minimum		14,00	14,50	25,80	8,00	7,30	12,90	18,40	21,10	56,80	4,20
Maximum		18,70	20,00	35,40	12,40	11,90	17,70	24,60	37,40	83,60	7,90

		T1IFLCA	T1IFRCR	T1IFRCA	T6M2	T6M1	T6M6	T6M9	T6PHL	T6PHR	T6M10
N	Valid	22	21	22	24	22	22	23	24	24	23
Mean		9,90	6,19	9,65	20,15	19,02	23,78	27,21	11,62	11,66	15,95
Median		10,15	6,20	9,80	20,20	19,15	24,00	27,00	11,70	11,65	16,00
Mode		10,40	5,70[a]	9,30[a]	18,80[a]	17,90[a]	24,00	26,80	12,00	11,50[a]	16,00[a]
Std. Deviation		1,51	1,03	1,39	1,52	1,25	1,56	1,77	1,36	1,45	1,16
Minimum		6,80	4,10	7,20	16,30	16,90	21,10	23,80	9,60	9,30	13,40
Maximum		12,20	8,40	12,00	23,10	21,50	27,60	30,60	15,10	14,80	17,80

		T6M11	T6SPL	T6TPW	T6IFLCA	T6IFRCA	T10M2	T10M1	T10M6	T10M9	T10PHL
N	Valid	24	13	13	23	21	26	25	24	25	25
Mean		17,13	20,93	64,17	11,21	11,27	22,47	21,64	27,80	33,20	14,94
Median		17,30	21,10	63,00	11,10	11,10	22,15	21,80	27,75	32,80	14,70
Mode		17,30	14,30[a]	63,00	10,30[a]	10,60[a]	21,20	20,80	27,30[a]	32,80	13,80
Std. Deviation		1,57	6,13	5,58	1,34	1,56	1,30	1,07	2,10	2,37	1,66
Minimum		13,70	14,30	56,30	9,00	9,00	20,80	18,50	24,20	28,30	12,00
Maximum		19,90	32,50	79,60	14,10	14,40	25,50	23,20	33,60	39,40	18,80

		T10PHR	T10M10	T10M11	T10SPL	T10TPW	T10IFLCA	T10IFRCA	L1M2	L1M1	L1M6
N	Valid	25	25	26	18	17	26	26	29	28	27
Mean		15,12	15,54	17,50	24,48	58,14	11,43	11,23	27,98	25,81	30,57
Median		15,00	15,60	17,60	23,70	58,80	11,40	11,00	28,20	26,00	30,30
Mode		14,10[a]	15,20	16,20[a]	22,60	55,80[a]	11,20[a]	9,90	27,10[a]	23,50[a]	32,20
Std. Deviation		1,45	1,11	1,41	3,14	4,86	1,96	1,96	1,34	1,88	3,03
Minimum		13,10	13,50	14,60	19,60	47,80	7,20	7,90	24,20	22,20	25,60
Maximum		18,80	18,30	20,60	30,00	65,30	14,40	15,10	30,20	29,60	39,50

		L1M9	L1PHL	L1PHR	L1M10	L1M11	L1SPL	L1TPW	L1IFLCR	L1IFLCA	L1IFRCR
N	Valid	29	29	29	27	28	19	9	28	27	27
Mean		38,73	15,53	16,13	17,16	22,80	29,60	70,50	7,76	12,17	8,25
Median		39,20	15,50	16,50	17,30	22,70	29,90	70,10	7,70	12,20	8,00
Mode		35,90[a]	16,80	16,50[a]	17,50	22,70	29,90	62,40[a]	7,70	11,90[a]	8,00
Std. Deviation		2,10	1,27	1,08	1,39	1,59	2,83	3,79	1,19	1,36	,85
Minimum		34,30	13,00	13,80	14,10	18,80	25,00	62,40	4,80	9,10	6,90
Maximum		42,80	18,00	17,60	20,00	26,80	35,50	74,90	9,80	15,50	10,20

		L1IFRCA	L5M2	L5M1	L5M6	L5M9	L5PHL	L5PHR	L5M10	L5M11	L5SPL
N	Valid	26	27	31	31	32	30	27	27	28	14
Mean		12,08	24,27	28,24	32,57	47,08	14,17	14,69	16,26	25,40	26,72
Median		12,15	24,30	27,90	32,40	47,65	14,10	14,80	15,80	25,65	26,15
Mode		13,20	24,30	27,50	32,20	48,80	11,80	12,60[a]	15,00	24,10[a]	22,50[a]
Std. Deviation		1,29	2,08	2,13	2,44	3,41	1,77	1,94	1,81	2,04	3,19
Minimum		9,30	19,20	23,80	24,80	39,30	10,80	11,40	13,00	21,50	22,50
Maximum		14,30	28,40	32,00	36,50	54,80	18,50	19,60	20,00	29,50	34,00

		L5TPW	L5IFLCR	L5IFLCA	L5IFRCR	L5IFRCA	FMM16	FMM7	HLM1	HCM7	FHBM18
N	Valid	12	30	28	26	26	10	8	24	32	35
Mean		83.31	5.84	9.63	5.99	9.61	36.15	29.94	313.13	62.81	46.04
Median		86.55	5.75	10.00	6.05	9.80	36.30	29.80	310.00	62.50	46.70
Mode		45.80[a]	4.80[a]	10.20	5.30	9.80	37.00	29.80	305.00[a]	62.00[a]	46.70
Std. Deviation		17.15	.99	1.54	.89	1.73	2.57	1.81	14.08	4.43	2.77
Minimum		45.80	4.30	6.40	4.20	5.80	32.80	27.00	291.00	53.00	38.80
Maximum		103.30	7.60	12.90	7.60	12.50	41.50	32.50	337.00	71.00	52.60

		FLM1	FCM8	BIWM2
N	Valid	26	34	12
Mean		437.85	86.21	272.92
Median		435.00	87.00	273.50
Mode		424.00[a]	89.00	259.00[a]
Std. Deviation		20.93	5.81	10.77
Minimum		391.00	76.00	259.00
Maximum		470.00	99.00	296.00

a. Multiple modes exist. The smallest value is shown

Females - Neolithic / Bronze Age

		AGEGROUP	C3M2	C3M1	C3M6	C3M9	C3PHL	C3PHR	C3M10	C3M11	C3SPL
N	Valid	54	39	37	38	37	34	35	27	36	14
Mean		1,39	12,17	12,15	14,97	19,38	6,21	6,09	14,65	22,28	13,00
Median		1,00	12,20	12,40	14,80	19,30	6,10	5,90	14,70	22,45	12,90
Mode		1,00	12,20	12,60	14,20[a]	20,80	5,50[a]	5,80	15,20[a]	21,00[a]	11,20
Std. Deviation		,63	,91	1,13	1,33	2,34	,94	,78	1,03	1,18	2,37
Minimum		1,00	10,20	10,00	12,50	14,90	4,20	4,80	12,10	19,20	9,40
Maximum		3,00	14,40	14,30	18,60	25,20	8,30	8,20	16,60	24,40	18,00

		C3TPW	C3IFLCR	C3IFLCA	C3IFRCR	C3IFRCA	C7M2	C7M1	C7M6	C7M9	C7PHL
N	Valid	17	34	35	36	36	35	35	34	35	33
Mean		48,68	5,73	7,02	6,04	7,34	13,32	12,95	15,09	25,06	6,54
Median		48,80	5,70	7,30	6,20	7,40	13,30	13,00	15,05	25,20	6,50
Mode		48,80[a]	5,70[a]	7,30[a]	3,80[a]	9,40	13,30	13,20[a]	13,60[a]	25,30	6,80
Std. Deviation		2,44	1,31	1,61	1,51	1,71	,97	1,02	1,19	2,12	,88
Minimum		44,20	3,60	3,80	3,30	3,90	11,50	10,60	12,60	19,60	4,80
Maximum		53,20	8,50	10,40	9,40	10,30	15,20	15,10	17,20	30,80	8,70

		C7PHR	C7M10	C7M11	C7SPL	C7TPW	C7IFLCR	C7IFLCA	C7IFRCR	C7IFRCA	T1M2
N	Valid	33	33	32	20	10	33	31	34	31	29
Mean		6,36	14,01	23,10	27,32	48,24	6,20	9,14	6,22	8,98	15,36
Median		6,50	14,30	22,95	28,10	46,15	6,20	9,10	6,15	9,20	15,30
Mode		5,30[a]	13,90[a]	22,80[a]	27,80[a]	34,30[a]	6,40	9,00	5,80	10,00	15,10
Std. Deviation		,92	1,00	1,49	4,14	14,64	,82	1,18	,83	1,11	1,21
Minimum		4,90	11,40	18,30	15,90	34,30	4,40	5,80	4,50	6,50	13,30
Maximum		8,80	15,30	25,50	37,10	88,10	8,30	10,90	7,90	10,80	17,80

		T1M1	T1M6	T1M9	T1PHL	T1PHR	T1M10	T1M11	T1SPL	T1TPW	T1IFLCR
N	Valid	28	28	29	30	29	29	27	15	17	27
Mean		14,68	15,54	26,37	8,30	8,36	14,51	19,91	27,52	68,28	6,25
Median		14,50	15,65	26,40	8,30	8,40	14,40	19,80	27,70	69,50	6,20
Mode		13,90[a]	15,80	26,20[a]	7,60[a]	8,00[a]	14,20	19,50	22,00[a]	68,80	5,80
Std. Deviation		1,19	1,32	2,00	1,07	1,16	,92	1,34	3,08	5,24	,72
Minimum		12,40	12,80	23,20	5,50	5,80	12,40	17,60	22,00	57,00	4,80
Maximum		17,40	18,00	29,70	10,70	10,50	16,10	23,60	33,10	74,90	7,50

		T1IFLCA	T1IFRCR	T1IFRCA	T6M2	T6M1	T6M6	T6M9	T6PHL	T6PHR	T6M10
N	Valid	27	25	27	28	29	28	29	29	29	28
Mean		9,96	6,28	9,85	18,81	17,71	21,61	24,55	10,48	10,32	15,62
Median		9,80	6,10	9,80	18,80	17,80	21,60	24,50	10,50	10,40	15,60
Mode		9,80	6,10	10,60	17,70[a]	16,00[a]	20,10[a]	23,20[a]	11,20	10,50[a]	14,60[a]
Std. Deviation		1,22	,98	1,33	1,34	1,23	1,88	1,68	,96	,88	,96
Minimum		6,90	4,30	6,40	15,90	15,70	18,00	22,10	8,90	8,40	14,30
Maximum		12,90	9,20	12,60	22,20	21,00	24,60	28,60	12,60	11,80	17,80

		T6M11	T6SPL	T6TPW	T6IFLCA	T6IFRCA	T10M2	T10M1	T10M6	T10M9	T10PHL
N	Valid	29	14	24	24	25	38	36	37	37	36
Mean		16,36	16,76	58,77	11,65	11,03	21,68	20,71	25,34	29,92	13,82
Median		16,00	15,90	58,80	11,45	11,20	21,60	20,60	25,50	29,70	13,95
Mode		15,80	9,00[a]	47,60[a]	13,20	9,90[a]	21,50	20,20[a]	24,60[a]	30,20	11,90[a]
Std. Deviation		1,68	5,29	4,99	1,84	1,80	1,75	1,54	1,93	2,54	1,38
Minimum		13,30	9,00	47,60	6,70	8,20	18,60	17,80	20,30	24,80	10,80
Maximum		20,20	26,20	67,00	14,70	16,20	26,40	24,50	28,80	35,00	16,80

		T10PHR	T10M10	T10M11	T10SPL	T10TPW	T10IFLCA	T10IFRCA	L1M2	L1M1	L1M6
N	Valid	38	37	36	22	26	35	37	41	39	39
Mean		14,04	15,28	16,79	23,30	52,57	11,38	11,15	26,68	24,99	27,45
Median		14,30	15,40	16,70	23,20	52,70	11,20	11,40	26,60	24,80	27,50
Mode		14,80	14,60[a]	16,20	22,60[a]	47,60[a]	12,00	12,60	27,50	24,40	27,30[a]
Std. Deviation		1,43	1,39	1,54	4,30	5,01	1,67	1,38	2,04	1,88	2,07
Minimum		10,90	10,80	13,50	18,20	44,40	7,90	8,80	23,40	21,30	22,90
Maximum		16,60	17,20	20,50	37,70	65,80	14,80	13,60	32,20	29,10	31,80

		L1M9	L1PHL	L1PHR	L1M10	L1M11	L1SPL	L1TPW	L1IFLCR	L1IFLCA	L1IFRCR
N	Valid	39	42	41	39	41	21	19	34	39	30
Mean		35,08	14,40	14,70	17,32	21,99	25,93	62,06	8,59	12,83	9,10
Median		35,10	14,40	15,00	17,20	22,10	25,70	64,00	8,60	12,90	9,05
Mode		32,80[a]	14,10	14,10[a]	16,80	20,90[a]	27,20	59,40[a]	8,50	13,70	8,30[a]
Std. Deviation		2,92	1,23	1,38	1,22	1,55	3,30	7,01	1,15	1,55	1,12
Minimum		29,20	11,10	11,80	15,10	18,20	18,80	44,20	6,00	9,10	6,80
Maximum		43,10	17,20	18,00	19,80	25,00	32,20	71,00	10,80	15,90	11,40

		L1IFRCA	L5M2	L5M1	L5M6	L5M9	L5PHL	L5PHR	L5M10	L5M11	L5SPL
N	Valid	38	42	44	44	46	41	42	35	40	22
Mean		12,61	23,48	26,67	31,29	44,77	13,07	13,62	16,40	25,38	22,90
Median		12,60	23,40	26,45	31,50	44,60	13,00	13,45	16,30	25,35	22,00
Mode		11,80[a]	23,70[a]	24,40[a]	31,00[a]	45,70[a]	11,20[a]	12,40	17,20	26,60	20,70[a]
Std. Deviation		1,31	2,24	2,54	2,66	3,11	1,87	1,77	2,38	2,75	3,21
Minimum		10,10	17,70	21,70	23,10	37,30	9,50	10,30	11,90	19,80	17,90
Maximum		15,60	27,00	32,30	35,90	52,10	17,70	17,80	23,00	31,00	30,90

		L5TPW	L5IFLCR	L5IFLCA	L5IFRCR	L5IFRCA	FMM16	FMM7	HLM1	HCM7	FHBM18
N	Valid	24	39	39	39	40	12	13	38	43	52
Mean		75,13	6,16	9,74	6,25	10,08	35,55	29,36	291,45	57,47	41,30
Median		81,25	6,10	9,80	6,10	10,25	34,95	29,20	288,00	57,00	41,10
Mode		81,20[a]	6,10	9,80	6,10[a]	7,80	38,40	25,00[a]	283,00[a]	55,00[a]	43,20
Std. Deviation		16,72	,84	1,82	,71	1,88	2,74	3,00	17,29	4,14	2,34
Minimum		40,00	4,50	5,10	4,80	6,30	31,90	25,00	260,00	48,00	36,50
Maximum		93,40	8,50	12,90	8,00	13,80	39,10	33,60	357,00	71,00	49,30

		FLM1	FCM8	BIWM2
N	Valid	40	45	19
Mean		409,05	76,16	259,95
Median		402,00	76,00	260,00
Mode		397,00	75,00	267,00
Std. Deviation		23,37	5,46	17,17
Minimum		381,00	65,00	234,00
Maximum		492,00	90,00	292,00

a. Multiple modes exist. The smallest value is shown

Males - Medieval Ages

		AGEGROUP	C3M2	C3M1	C3M6	C3M9	C3PHL	C3PHR	C3M10	C3M11	C3SPL
N	Valid	92	63	62	59	57	60	62	53	60	21
Mean		1.83	13.76	13.71	15.93	18.58	6.76	6.77	15.21	24.31	16.66
Median		2.00	13.80	13.80	15.90	18.40	6.70	6.65	15.30	24.15	16.60
Mode		2.00	13.80	12.90[a]	15.90	18.10	6.50	5.80	14.30	24.20	14.10
Std. Deviation		.57	1.07	1.21	1.29	1.82	.87	.81	1.48	1.32	3.47
Minimum		1.00	10.80	11.10	12.40	14.00	4.20	5.40	11.80	20.10	11.10
Maximum		3.00	15.80	16.30	18.80	22.50	9.00	8.30	18.10	27.00	22.70

		C3TPW	C3IFLCR	C3IFLCA	C3IFRCR	C3IFRCA	C7M2	C7M1	C7M6	C7M9	C7PHL
N	Valid	35	60	60	63	62	68	67	68	66	64
Mean		54.93	6.41	7.84	6.29	7.75	14.94	14.08	17.19	26.38	7.20
Median		54.40	6.40	7.75	6.20	7.60	15.00	14.20	17.30	26.45	7.05
Mode		57.20	6.80	7.80	5.30[a]	7.80	14.80[a]	13.80[a]	17.80	25.80	6.90
Std. Deviation		4.07	1.04	1.25	.93	1.28	.99	1.35	1.44	2.35	.85
Minimum		47.30	4.40	5.20	4.40	4.20	12.60	10.20	13.90	21.20	5.30
Maximum		65.40	9.20	10.80	9.00	10.60	17.90	17.20	20.10	32.00	9.20

		C7PHR	C7M10	C7M11	C7SPL	C7TPW	C7IFLCR	C7IFLCA	C7IFRCR	C7IFRCA	T1M2
N	Valid	63	61	68	37	22	64	61	65	64	70
Mean		7.08	14.94	25.11	29.04	68.37	6.16	9.88	6.28	9.85	17.25
Median		7.00	14.80	25.25	29.20	72.80	6.20	9.80	6.20	9.85	17.30
Mode		6.50	15.10	23.20[a]	26.50[a]	69.10[a]	6.50	9.00[a]	6.20	10.40	16.80
Std. Deviation		.79	1.30	2.21	4.10	12.93	.90	1.23	.76	1.24	1.30
Minimum		5.20	12.30	17.40	17.80	39.90	4.30	7.70	4.80	7.20	13.60
Maximum		8.90	17.90	30.60	37.90	84.60	8.10	12.90	7.80	12.90	19.90

		T1M1	T1M6	T1M9	T1PHL	T1PHR	T1M10	T1M11	T1SPL	T1TPW	T1IFLCR
N	Valid	70	68	70	66	67	61	62	38	52	65
Mean		16,11	17,33	28,33	9,31	9,35	15,44	22,29	31,25	78,40	6,42
Median		16,00	17,40	28,35	9,30	9,20	15,40	22,00	32,00	77,40	6,20
Mode		15,80[a]	16,50	27,10[a]	9,30	8,20[a]	15,80	21,80	32,00[a]	73,20[a]	6,10[a]
Std. Deviation		1,46	1,39	2,93	1,18	1,17	1,02	1,92	4,30	6,65	,96
Minimum		12,50	12,90	22,80	6,80	7,00	13,60	17,60	20,70	50,20	4,60
Maximum		19,70	19,90	34,70	12,30	12,00	17,70	27,70	39,50	92,20	8,60

		T1IFLCA	T1IFRCR	T1IFRCA	T6M2	T6M1	T6M6	T6M9	T6PHL	T6PHR	T6M10
N	Valid	63	61	60	64	63	60	62	59	61	51
Mean		10,09	6,23	10,13	21,19	19,03	25,98	28,12	12,02	12,22	16,12
Median		10,00	6,30	10,15	21,40	18,90	26,00	28,20	12,00	12,20	16,10
Mode		11,50	6,50[a]	8,80[a]	19,00[a]	19,80	26,80	26,20	11,80	12,80	17,60
Std. Deviation		1,41	,86	1,21	1,58	1,37	2,15	2,08	1,17	1,24	1,08
Minimum		6,80	4,50	7,50	17,30	15,10	21,60	22,00	8,80	9,30	13,80
Maximum		13,20	8,50	13,20	23,30	22,20	31,00	32,40	14,00	14,50	18,10

		T6M11	T6SPL	T6TPW	T6IFLCA	T6IFRCA	T10M2	T10M1	T10M6	T10M9	T10PHL
N	Valid	60	14	30	45	46	71	70	69	70	67
Mean		17,19	19,39	65,25	11,66	11,36	24,10	22,45	30,29	34,39	15,55
Median		17,25	19,00	65,05	11,50	11,50	24,20	22,25	30,60	34,80	15,30
Mode		16,10	10,30[a]	61,80[a]	11,40	11,90	22,50	22,00	28,80[a]	34,80	14,60
Std. Deviation		1,45	6,21	6,04	2,04	1,69	1,59	1,58	2,71	3,16	1,30
Minimum		14,20	10,30	48,00	7,50	7,90	19,40	18,30	25,10	24,20	12,87
Maximum		21,10	29,90	74,90	16,10	15,80	27,80	26,80	35,80	39,90	19,40

		T10PHR	T10M10	T10M11	T10SPL	T10TPW	T10IFLCA	T10IFRCA	L1M2	L1M1	L1M6
N	Valid	67	64	67	24	40	60	61	82	77	72
Mean		15,37	16,23	18,54	26,59	60,56	12,31	11,86	28,06	25,94	31,66
Median		15,30	16,00	18,30	27,45	60,20	12,55	12,00	27,95	26,20	31,80
Mode		14,80[a]	15,80	18,20	24,20	51,40[a]	11,20[a]	12,00	27,20[a]	27,10	30,10[a]
Std. Deviation		1,30	1,32	1,73	4,93	5,88	1,75	1,67	1,69	2,04	2,76
Minimum		12,60	13,70	15,20	12,70	48,00	8,70	8,30	24,20	21,90	25,20
Maximum		19,00	19,80	22,50	35,40	72,20	16,60	16,50	32,70	30,50	37,80

		L1M9	L1PHL	L1PHR	L1M10	L1M11	L1SPL	L1TPW	L1IFLCR	L1IFLCA	L1IFRCR
N	Valid	81	77	78	69	74	27	27	71	66	68
Mean		40,49	15,44	15,76	17,91	23,90	29,90	72,67	8,23	12,70	8,30
Median		41,10	15,30	15,70	17,80	23,85	29,40	72,00	8,30	12,80	8,40
Mode		39,80	14,00[a]	14,60[a]	17,80[a]	23,10	28,10	72,00	8,30	11,80[a]	8,40
Std. Deviation		3,21	1,30	1,31	1,38	1,55	4,50	11,01	1,05	1,49	1,01
Minimum		30,20	12,10	13,20	14,60	20,40	18,50	37,80	6,20	9,80	6,10
Maximum		46,00	18,50	19,10	21,50	28,60	37,60	89,80	10,40	16,30	10,50

		L1IFRCA	L5M2	L5M1	L5M6	L5M9	L5PHL	L5PHR	L5M10	L5M11	L5SPL
N	Valid	66	73	71	69	73	71	71	59	64	30
Mean		12,64	24,78	28,66	33,82	48,05	14,17	14,70	16,78	26,52	24,78
Median		12,35	24,90	28,70	33,70	48,60	14,00	14,60	16,50	26,80	25,00
Mode		11,80	23,80[a]	29,20	32,10	48,80[a]	12,20[a]	14,80	15,50	23,80[a]	23,80[a]
Std. Deviation		1,57	2,04	2,63	3,24	4,49	1,86	2,05	2,12	2,29	3,94
Minimum		9,60	21,20	21,90	25,60	36,70	11,10	10,90	12,40	21,10	17,60
Maximum		16,80	30,40	34,00	41,80	58,30	18,90	20,00	22,80	32,00	33,20

		L5TPW	L5IFLCR	L5IFLCA	L5IFRCR	L5IFRCA	FMM16	FMM7	HLM1	HCM7	FHBM18
N	Valid	28	67	59	67	58	18	17	66	85	80
Mean		83.75	5.88	9.98	6.05	9.90	37.23	32.19	334.26	65.93	48.99
Median		89.90	5.80	9.80	6.20	9.85	37.00	31.50	331.00	65.00	48.80
Mode		96.00	5.00	7.00[a]	6.20	9.80	35.70[a]	30.90	328.00	65.00	48.00
Std. Deviation		18.79	.87	1.85	.95	1.68	2.46	2.55	17.93	4.18	3.03
Minimum		44.80	4.00	6.40	4.00	6.40	32.20	27.90	294.00	57.00	41.20
Maximum		102.10	8.60	14.20	9.00	13.80	41.20	38.90	368.00	78.00	56.40

		FLM1	FCM8	BIWM2
N	Valid	68	83	27
Mean		464.40	90.90	282.15
Median		464.00	91.00	283.00
Mode		455.00	85.00[a]	280.00[a]
Std. Deviation		27.66	6.43	17.49
Minimum		376.00	75.00	230.00
Maximum		522.00	108.00	317.00

a. Multiple modes exist. The smallest value is shown

Females - Medieval Ages

		AGEGROUP	C3M2	C3M1	C3M6	C3M9	C3PHL	C3PHR	C3M10	C3M11	C3SPL
N	Valid	81	63	64	61	61	63	63	50	61	22
Mean		1,64	12,43	12,27	14,67	18,13	5,92	6,02	14,84	23,33	13,12
Median		1,00	12,50	12,20	14,60	17,90	5,80	6,00	15,05	23,20	13,15
Mode		1,00	12,80	12,80	14,20[a]	18,00	5,20	6,30	15,60	23,30[a]	11,50[a]
Std. Deviation		,73	1,10	1,33	1,20	1,84	,87	,73	1,28	1,33	1,71
Minimum		1,00	9,50	9,10	12,10	14,60	4,30	4,60	11,70	20,10	10,10
Maximum		3,00	15,00	17,10	18,00	22,80	8,20	8,50	17,70	28,50	16,30

		C3TPW	C3IFLCR	C3IFLCA	C3IFRCR	C3IFRCA	C7M2	C7M1	C7M6	C7M9	C7PHL
N	Valid	36	61	61	61	61	65	66	65	64	64
Mean		49,70	6,64	8,21	6,49	8,19	13,75	12,87	15,67	24,85	6,74
Median		49,35	6,50	8,50	6,70	8,30	13,80	12,90	15,70	24,50	6,75
Mode		47,80[a]	6,40[a]	7,10[a]	6,80	7,60[a]	12,60[a]	11,80[a]	15,80	24,20[a]	6,20[a]
Std. Deviation		3,84	1,05	1,60	1,08	1,44	1,08	1,12	1,40	2,20	,95
Minimum		43,20	3,80	4,80	4,20	4,70	10,80	10,50	12,80	20,80	4,20
Maximum		62,00	8,80	11,30	9,20	12,10	16,60	15,40	19,00	32,00	9,10

		C7PHR	C7M10	C7M11	C7SPL	C7TPW	C7IFLCR	C7IFLCA	C7IFRCR	C7IFRCA	T1M2
N	Valid	68	60	63	35	17	58	57	59	58	69
Mean		6,66	14,45	24,57	25,59	58,86	6,32	9,71	6,39	9,57	15,71
Median		6,60	14,50	24,60	26,20	65,60	6,30	9,80	6,30	9,70	15,60
Mode		5,80[a]	14,60	25,80	24,00[a]	21,30[a]	6,80	9,80	6,10	9,80	15,40[a]
Std. Deviation		,79	1,41	1,70	2,91	17,35	,95	1,28	,85	1,27	1,22
Minimum		4,90	10,60	20,60	19,60	21,30	4,20	6,50	4,20	6,30	13,20
Maximum		8,80	18,10	28,90	29,50	75,00	8,80	12,20	8,80	12,20	19,30

		T1M1	T1M6	T1M9	T1PHL	T1PHR	T1M10	T1M11	T1SPL	T1TPW	T1IFLCR
N	Valid	68	64	66	63	69	56	65	25	47	61
Mean		14,56	15,83	26,28	8,47	8,39	14,90	21,52	26,69	71,08	6,34
Median		14,60	15,85	26,35	8,60	8,30	14,75	21,20	26,90	71,40	6,30
Mode		14,00[a]	15,30[a]	26,00	8,60	7,80	14,50	20,50	22,60[a]	68,50[a]	6,20
Std. Deviation		1,09	1,37	2,61	1,10	1,01	1,32	1,72	3,64	5,14	,80
Minimum		12,10	12,80	21,40	5,90	5,80	11,80	18,40	19,40	58,20	4,50
Maximum		17,40	18,60	32,30	10,80	10,60	18,50	25,70	32,90	88,40	8,80

		T1IFLCA	T1IFRCR	T1IFRCA	T6M2	T6M1	T6M6	T6M9	T6PHL	T6PHR	T6M10
N	Valid	59	65	60	67	66	65	67	62	63	54
Mean		10,27	6,30	10,09	19,05	17,39	23,17	24,95	10,27	10,49	15,86
Median		10,30	6,40	10,35	19,00	17,35	23,60	24,90	10,15	10,50	15,85
Mode		9,50[a]	6,50[a]	11,30	18,50[a]	16,90[a]	24,00	22,80[a]	9,80	10,80	16,40
Std. Deviation		1,59	,84	1,46	1,25	1,24	2,08	1,67	,80	,83	1,22
Minimum		6,50	4,40	6,40	15,70	14,30	18,10	21,80	8,10	8,80	13,30
Maximum		13,80	8,40	13,50	21,40	20,20	28,30	30,10	12,40	12,50	19,10

		T6M11	T6SPL	T6TPW	T6IFLCA	T6IFRCA	T10M2	T10M1	T10M6	T10M9	T10PHL
N	Valid	62	18	41	50	47	67	66	67	68	65
Mean		16,49	14,81	59,67	12,17	12,06	21,67	20,82	26,39	30,55	13,85
Median		16,40	14,95	58,80	12,25	12,00	21,80	21,05	26,30	30,75	13,90
Mode		15,20[a]	6,80[a]	57,20	11,00[a]	13,00	21,90	21,20	27,50	28,80	14,00
Std. Deviation		1,44	4,53	5,96	1,58	1,45	1,57	1,67	2,19	2,27	1,22
Minimum		13,00	6,80	45,50	8,50	9,00	16,40	16,00	21,30	25,20	10,50
Maximum		20,40	25,60	77,20	15,20	15,40	26,00	26,10	32,90	36,60	16,80

		T10PHR	T10M10	T10M11	T10SPL	T10TPW	T10IFLCA	T10IFRCA	L1M2	L1M1	L1M6
N	Valid	65	58	63	22	41	55	55	71	70	66
Mean		13,84	15,61	17,44	23,65	54,87	12,59	12,09	26,06	24,59	27,53
Median		13,80	15,65	17,40	24,45	55,00	12,60	12,00	26,20	24,50	27,40
Mode		13,80	15,90	17,30[a]	24,80[a]	53,60[a]	13,20	11,30[a]	26,50	24,50[a]	26,20
Std. Deviation		1,09	1,41	1,32	2,88	5,25	1,40	1,61	1,67	1,81	2,34
Minimum		10,20	11,90	14,50	15,10	42,10	8,70	7,80	22,00	19,20	21,70
Maximum		16,20	19,60	21,30	28,70	65,40	15,80	15,10	30,10	28,60	32,80

		L1M9	L1PHL	L1PHR	L1M10	L1M11	L1SPL	L1TPW	L1IFLCR	L1IFLCA	L1IFRCR
N	Valid	69	66	71	58	69	22	23	58	53	57
Mean		35,76	14,25	14,39	17,73	22,62	25,33	64,09	8,71	12,98	8,54
Median		36,00	14,10	14,50	17,70	22,50	25,25	65,60	8,50	12,80	8,60
Mode		38,40	15,30	15,10	18,00[a]	24,10	14,80[a]	36,20[a]	8,50	12,20	8,30[a]
Std. Deviation		2,99	1,23	1,40	1,47	1,75	3,86	8,45	1,17	1,36	1,14
Minimum		26,60	11,40	10,70	15,00	18,00	14,80	36,20	6,20	10,00	6,30
Maximum		43,20	17,40	18,10	21,10	27,10	32,60	77,40	11,90	16,00	11,40

		L1IFRCA	L5M2	L5M1	L5M6	L5M9	L5PHL	L5PHR	L5M10	L5M11	L5SPL
N	Valid	56	68	62	62	67	63	64	57	61	24
Mean		12,89	23,42	26,85	31,21	44,23	12,77	13,62	16,94	26,16	24,20
Median		13,00	23,85	26,70	31,30	43,20	12,80	13,25	16,70	25,90	24,00
Mode		12,40	25,30	25,50[a]	32,20[a]	41,80[a]	12,20[a]	12,80	15,20[a]	25,30[a]	25,00[a]
Std. Deviation		1,36	1,99	2,65	2,73	3,88	1,87	1,67	2,14	2,53	3,72
Minimum		10,00	19,00	21,50	24,10	35,00	8,60	9,50	12,40	21,20	17,70
Maximum		15,50	27,80	32,60	39,00	54,80	17,20	18,60	22,50	33,20	33,80

		L5TPW	L5IFLCR	L5IFLCA	L5IFRCR	L5IFRCA	FMM16	FMM7	HLM1	HCM7	FHBM18
N	Valid	31	64	59	61	58	17	17	54	75	74
Mean		76.99	6.27	10.60	6.46	10.44	35.90	29.18	303.89	56.57	43.26
Median		81.10	6.30	10.50	6.30	10.60	35.80	28.80	305.00	56.00	43.20
Mode		87.60	6.80	10.40	6.20[a]	11.80	36.00	28.20	292.00	55.00	43.20
Std. Deviation		15.01	1.00	1.61	1.10	1.71	2.28	1.86	19.11	3.56	2.23
Minimum		41.40	4.20	7.20	4.30	5.80	33.10	26.20	261.00	49.00	38.00
Maximum		97.20	9.20	14.10	9.20	13.90	41.40	32.10	351.00	66.00	47.60

		FLM1	FCM8	BIWM2
N	Valid	64	77	33
Mean		429.63	80.60	271.79
Median		435.50	80.00	270.00
Mode		442.00	79.00	258.00[a]
Std. Deviation		24.88	5.09	13.44
Minimum		379.00	70.00	243.00
Maximum		476.00	95.00	303.00

a. Multiple modes exist. The smallest value is shown

Males - Modern

		AGEGROUP	C3M2	C3M1	C3M6	C3M9	C3PHL	C3PHR	C3M10	C3M11	C3SPL
N	Valid	41	38	38	36	37	35	33	34	38	11
Mean		2,02	14,57	14,15	16,20	19,27	7,33	7,26	15,93	24,54	16,95
Median		2,00	14,65	14,00	16,10	19,40	7,00	7,10	15,90	24,60	16,80
Mode		2,00[a]	13,20[a]	14,00[a]	14,00[a]	19,80	6,90	7,00	15,90[a]	24,60	12,70[a]
Std. Deviation		,82	1,36	1,01	1,49	1,81	1,11	1,03	1,45	1,69	2,96
Minimum		1,00	10,50	11,80	13,40	16,70	5,50	5,40	13,10	19,90	12,70
Maximum		3,00	16,80	16,80	18,80	23,30	9,80	9,10	19,20	27,10	21,40

		C3TPW	C3IFLCR	C3IFLCA	C3IFRCR	C3IFRCA	C7M2	C7M1	C7M6	C7M9	C7PHL
N	Valid	22	37	35	34	35	38	37	36	36	36
Mean		56,10	6,82	8,21	6,49	8,20	15,15	13,72	17,65	26,55	7,54
Median		55,70	7,00	8,20	6,50	8,30	15,20	13,70	17,35	26,50	7,55
Mode		53,00[a]	7,00[a]	6,80	5,80	8,30	15,20[a]	13,20	16,50[a]	24,60[a]	6,40
Std. Deviation		3,76	,86	1,33	,94	1,30	1,28	1,45	1,73	2,24	,94
Minimum		47,80	4,80	5,30	4,20	4,50	12,20	10,10	14,90	22,20	6,20
Maximum		64,40	8,70	11,90	8,40	10,80	17,50	16,40	21,50	32,50	10,40

		C7PHR	C7M10	C7M11	C7SPL	C7TPW	C7IFLCR	C7IFLCA	C7IFRCR	C7IFRCA	T1M2
N	Valid	38	38	38	23	7	35	38	35	37	40
Mean		7,54	15,10	26,14	31,53	66,21	6,30	10,05	6,55	10,10	17,29
Median		7,50	15,30	26,30	32,20	70,30	6,50	10,00	6,60	10,10	17,05
Mode		8,80	15,50	26,40	23,10[a]	25,80[a]	7,00	11,00	6,80	9,60[a]	16,80
Std. Deviation		,97	1,53	1,73	4,30	18,40	,93	1,49	,73	1,18	1,41
Minimum		5,90	10,60	22,70	23,10	25,80	4,80	6,50	5,10	7,50	14,00
Maximum		9,20	18,20	30,30	39,80	82,20	8,50	13,50	8,10	12,00	19,70

		T1M1	T1M6	T1M9	T1PHL	T1PHR	T1M10	T1M11	T1SPL	T1TPW	T1IFLCR
N	Valid	38	34	38	40	39	38	40	20	35	38
Mean		16,03	17,76	28,93	9,31	9,12	15,78	23,26	33,24	79,07	6,56
Median		15,85	17,40	28,70	9,55	9,20	16,10	23,20	33,60	78,30	6,65
Mode		16,30	17,10	25,60[a]	7,80	9,80	16,10	21,50[a]	30,10[a]	82,90	7,30
Std. Deviation		1,29	1,97	2,78	1,26	1,28	1,24	1,78	3,57	5,09	1,01
Minimum		13,20	13,80	23,40	6,70	5,40	12,70	19,50	23,90	69,80	4,60
Maximum		18,70	22,00	35,90	11,80	11,80	18,90	27,70	37,60	88,90	8,80

		T1IFLCA	T1IFRCR	T1IFRCA	T6M2	T6M1	T6M6	T6M9	T6PHL	T6PHR	T6M10
N	Valid	39	35	39	36	35	34	36	35	36	34
Mean		10,87	6,50	10,56	21,01	18,99	26,25	27,90	12,15	12,56	16,67
Median		10,70	6,30	10,70	21,20	19,10	26,05	27,95	12,20	12,60	16,70
Mode		10,50[a]	6,10	9,80[a]	21,60	17,70[a]	25,50	25,20[a]	12,20	11,80	16,80
Std. Deviation		1,50	,96	1,46	1,36	1,65	2,44	2,27	1,13	1,04	1,26
Minimum		7,60	5,10	7,20	16,30	15,20	21,00	23,60	9,80	10,60	14,50
Maximum		13,90	8,60	13,90	24,00	22,10	32,30	32,20	14,90	14,90	19,50

		T6M11	T6SPL	T6TPW	T6IFLCA	T6IFRCA	T10M2	T10M1	T10M6	T10M9	T10PHL
N	Valid	36	13	27	32	32	38	34	31	39	40
Mean		17,66	18,70	65,50	13,35	12,67	23,83	22,24	31,25	34,66	15,72
Median		17,45	17,60	66,00	13,45	12,60	23,95	22,50	31,30	35,80	15,90
Mode		16,10	10,50[a]	55,50[a]	12,40[a]	12,20[a]	23,20[a]	23,60	28,80	35,80[a]	14,90
Std. Deviation		1,47	5,44	4,48	1,76	1,28	1,46	1,52	3,28	3,37	1,43
Minimum		13,80	10,50	55,50	9,30	9,70	18,00	17,80	24,50	25,20	12,60
Maximum		21,00	27,00	75,80	16,60	15,50	26,00	24,80	38,20	40,20	18,90

		T10PHR	T10M10	T10M11	T10SPL	T10TPW	T10IFLCA	T10IFRCA	L1M2	L1M1	L1M6
N	Valid	38	38	40	11	24	38	37	36	36	33
Mean		15,84	16,44	18,60	30,41	63,04	13,06	12,94	27,92	25,45	32,92
Median		15,95	16,30	18,50	29,70	63,80	13,05	12,70	28,20	25,60	33,30
Mode		16,10[a]	16,30	18,00	26,60	65,20	13,00	12,50	26,10[a]	23,90[a]	27,60[a]
Std. Deviation		1,22	1,58	1,80	3,74	4,86	1,81	1,96	1,61	2,16	2,88
Minimum		13,40	13,20	14,10	26,40	48,00	8,60	9,10	22,70	19,80	27,60
Maximum		18,90	19,90	22,60	37,90	69,40	16,40	16,30	31,60	29,60	37,70

		L1M9	L1PHL	L1PHR	L1M10	L1M11	L1SPL	L1TPW	L1IFLCR	L1IFLCA	L1IFRCR
N	Valid	37	35	36	34	35	8	16	34	34	32
Mean		40,99	16,36	16,46	18,25	24,37	32,29	75,07	8,58	13,06	8,92
Median		41,00	16,40	16,45	18,75	24,20	32,10	76,60	8,55	13,00	8,90
Mode		39,80	15,20[a]	16,10[a]	18,80[a]	21,90	22,10[a]	76,60	8,90	15,20	8,60[a]
Std. Deviation		3,38	1,34	1,63	1,71	2,02	6,11	11,45	1,30	2,32	1,29
Minimum		32,30	14,10	12,00	14,50	20,00	22,10	40,20	5,30	8,00	6,30
Maximum		45,40	19,30	19,70	21,80	28,50	41,50	92,20	11,80	17,40	11,40

		L1IFRCA	L5M2	L5M1	L5M6	L5M9	L5PHL	L5PHR	L5M10	L5M11	L5SPL
N	Valid	34	36	37	32	38	38	37	35	38	11
Mean		12,99	24,09	28,92	34,53	47,73	13,92	14,55	17,73	26,27	29,93
Median		12,95	24,30	29,10	34,90	47,70	13,80	14,50	17,70	26,65	30,60
Mode		11,10	22,60	29,10	33,20[a]	43,60	13,80	14,80	16,20[a]	23,20	24,60
Std. Deviation		1,99	1,93	2,31	3,10	5,10	1,62	1,85	2,29	3,04	3,89
Minimum		8,30	20,10	20,50	28,20	34,70	10,40	10,90	12,60	20,20	24,60
Maximum		15,80	27,80	33,00	41,20	57,20	18,30	19,80	22,20	32,70	36,30

		L5TPW	L5IFLCR	L5IFLCA	L5IFRCR	L5IFRCA	FMM16	FMM7	HLM1	HCM7	FHBM18
N	Valid	18	38	37	35	36	28	28	36	40	39
Mean		91,45	6,53	10,09	6,35	9,79	37,30	32,39	325,50	67,28	49,39
Median		93,80	6,40	10,00	6,10	10,00	38,05	32,75	325,00	68,00	49,10
Mode		79,80	5,30[a]	8,20[a]	6,00[a]	9,80[a]	33,30[a]	29,70[a]	325,00	65,00	49,10
Std. Deviation		7,60	,97	2,27	,96	1,71	2,58	2,25	14,53	5,55	3,18
Minimum		79,80	4,50	5,50	4,70	6,70	30,60	28,60	286,00	56,00	40,80
Maximum		104,00	8,50	14,80	8,40	13,00	40,90	36,20	350,00	78,00	56,20

		FLM1	FCM8	BIWM2
N	Valid	36	39	24
Mean		453,44	89,44	289,79
Median		454,50	88,00	290,00
Mode		409,00[a]	88,00	275,00
Std. Deviation		25,25	6,91	16,64
Minimum		391,00	72,00	256,00
Maximum		514,00	103,00	322,00

a. Multiple modes exist. The smallest value is shown

Females - Modern

		AGEGROUP	C3M2	C3M1	C3M6	C3M9	C3PHL	C3PHR	C3M10	C3M11	C3SPL
N	Valid	30	26	24	25	25	27	26	24	26	9
Mean		1,73	12,77	12,52	14,72	18,09	6,22	6,25	15,44	23,86	16,03
Median		1,50	12,95	12,45	14,80	17,80	6,40	6,35	15,50	23,90	14,60
Mode		1,00	13,30	12,00[a]	14,10	17,80	5,30[a]	4,80	13,20[a]	22,80[a]	12,30[a]
Std. Deviation		,83	1,35	1,21	1,41	2,37	,93	,98	1,48	1,58	4,05
Minimum		1,00	10,30	10,40	11,80	13,70	4,60	4,80	13,10	20,90	12,30
Maximum		3,00	15,70	15,50	17,30	24,20	8,10	8,30	18,50	27,40	25,50

		C3TPW	C3IFLCR	C3IFLCA	C3IFRCR	C3IFRCA	C7M2	C7M1	C7M6	C7M9	C7PHL
N	Valid	17	26	27	26	26	26	25	26	26	26
Mean		51,85	6,67	8,27	6,61	8,13	13,63	12,76	15,97	24,37	6,50
Median		53,00	6,85	8,20	6,80	8,15	13,75	12,90	16,30	25,10	6,45
Mode		53,30	5,30[a]	6,20[a]	7,30	7,90	13,40[a]	12,20	16,80	23,20[a]	5,50[a]
Std. Deviation		3,91	1,08	1,25	1,05	1,32	1,41	1,40	1,50	1,86	,97
Minimum		42,20	4,30	5,80	4,30	5,90	10,70	10,30	13,40	19,80	4,80
Maximum		56,90	8,60	10,60	8,60	10,70	16,60	15,20	19,20	26,50	9,00

		C7PHR	C7M10	C7M11	C7SPL	C7TPW	C7IFLCR	C7IFLCA	C7IFRCR	C7IFRCA	T1M2
N	Valid	27	26	27	14	6	26	26	25	24	28
Mean		6,62	14,51	25,74	26,11	52,88	6,61	9,96	6,76	9,81	15,74
Median		6,50	14,60	25,60	26,35	61,60	6,60	10,15	6,90	9,95	15,65
Mode		6,20[a]	14,60	24,10[a]	20,90[a]	22,20[a]	6,50[a]	9,30	7,20	10,40	14,90[a]
Std. Deviation		1,08	1,34	1,78	2,86	21,79	,85	1,31	,84	1,17	1,38
Minimum		4,80	11,40	22,20	20,90	22,20	4,40	6,10	5,20	7,00	13,10
Maximum		9,40	16,90	29,50	30,70	76,80	8,20	11,80	8,20	11,90	18,60

		T1M1	T1M6	T1M9	T1PHL	T1PHR	T1M10	T1M11	T1SPL	T1TPW	T1IFLCR
N	Valid	27	27	28	28	28	28	28	13	25	28
Mean		14,46	16,01	26,10	8,37	8,27	15,33	22,21	29,13	72,53	6,61
Median		14,30	16,30	26,10	8,60	8,45	15,30	22,30	29,80	73,50	6,50
Mode		13,40	16,50[a]	24,10[a]	6,70[a]	6,70[a]	14,20[a]	20,20[a]	23,60[a]	70,90[a]	6,50
Std. Deviation		1,40	1,60	2,06	1,27	1,08	1,18	1,68	3,02	3,90	1,01
Minimum		11,60	12,20	21,20	6,20	6,40	12,80	18,90	23,60	63,50	4,40
Maximum		17,30	19,90	32,10	11,40	10,20	17,40	25,10	33,50	77,70	8,40

		T1IFLCA	T1IFRCR	T1IFRCA	T6M2	T6M1	T6M6	T6M9	T6PHL	T6PHR	T6M10
N	Valid	27	28	27	26	27	27	28	27	27	26
Mean		10,34	6,72	10,42	19,83	17,73	23,57	24,60	10,54	10,80	16,16
Median		10,60	6,75	10,50	19,70	17,80	23,50	24,35	10,30	10,70	16,25
Mode		11,20	5,90[a]	10,20[a]	18,90	16,80	24,20	23,00[a]	10,20	9,60[a]	15,30
Std. Deviation		1,34	,92	1,54	1,40	1,17	2,31	1,96	1,25	1,20	1,02
Minimum		8,10	4,50	6,30	17,50	15,80	20,60	20,20	8,60	8,60	13,90
Maximum		12,20	8,20	12,70	22,70	19,60	29,50	29,60	13,60	14,20	18,00

		T6M11	T6SPL	T6TPW	T6IFLCA	T6IFRCA	T10M2	T10M1	T10M6	T10M9	T10PHL
N	Valid	27	11	22	24	25	28	28	26	29	28
Mean		16,88	17,01	60,93	12,42	11,47	22,05	21,45	27,28	30,98	14,27
Median		17,10	16,30	61,25	12,35	12,00	21,95	21,15	26,80	30,70	14,25
Mode		15,10[a]	7,80[a]	62,60	10,50[a]	8,50[a]	19,60[a]	20,60	25,10[a]	30,00[a]	12,40[a]
Std. Deviation		1,75	5,64	4,23	1,97	1,69	1,45	1,75	2,47	2,35	1,70
Minimum		13,80	7,80	54,20	7,70	8,30	19,60	16,40	22,90	26,10	11,20
Maximum		20,80	26,30	70,10	16,80	14,90	24,80	25,60	32,80	36,50	18,70

		T10PHR	T10M10	T10M11	T10SPL	T10TPW	T10IFLCA	T10IFRCA	L1M2	L1M1	L1M6
N	Valid	27	27	28	13	22	28	27	27	25	25
Mean		14,34	16,44	17,85	26,05	58,08	12,66	12,62	26,44	24,97	28,17
Median		14,20	16,60	17,75	26,30	57,95	12,85	12,60	26,80	25,10	27,80
Mode		11,90[a]	15,80[a]	16,70[a]	20,20[a]	49,60[a]	12,20[a]	12,10[a]	26,80	22,20[a]	29,40
Std. Deviation		1,68	1,30	1,71	4,13	4,73	1,12	1,15	2,04	1,84	2,64
Minimum		11,90	13,50	14,80	20,20	49,60	10,00	10,70	22,40	21,70	24,00
Maximum		17,80	19,00	21,40	32,80	67,90	14,70	15,20	30,60	28,00	34,80

		L1M9	L1PHL	L1PHR	L1M10	L1M11	L1SPL	L1TPW	L1IFLCR	L1IFLCA	L1IFRCR
N	Valid	28	27	28	28	28	13	15	28	27	27
Mean		35,92	14,36	14,63	18,42	23,18	29,24	68,30	9,12	13,56	9,48
Median		35,70	14,20	14,65	18,35	23,45	30,20	70,20	9,15	13,90	9,20
Mode		34,90[a]	13,20[a]	12,80[a]	17,80	23,90	28,50[a]	57,60[a]	6,70[a]	14,80	9,20
Std. Deviation		2,80	1,36	1,53	1,55	1,77	3,99	6,53	1,37	1,45	1,30
Minimum		30,60	12,10	11,10	15,50	20,00	20,00	57,60	6,70	10,30	7,20
Maximum		41,50	17,20	18,40	21,60	27,50	33,80	77,10	11,30	16,40	12,00

		L1IFRCA	L5M2	L5M1	L5M6	L5M9	L5PHL	L5PHR	L5M10	L5M11	L5SPL
N	Valid	27	26	24	23	27	26	26	25	27	13
Mean		13,43	23,60	28,12	30,38	42,57	12,65	13,29	17,71	26,52	26,74
Median		13,50	23,60	28,40	30,50	43,10	12,95	12,75	17,30	26,00	26,80
Mode		11,80[a]	22,40[a]	26,80[a]	30,50[a]	40,20[a]	13,00[a]	12,60[a]	15,90[a]	24,20[a]	23,60[a]
Std. Deviation		1,35	1,79	2,08	2,68	3,22	2,23	2,09	1,90	2,93	4,06
Minimum		11,10	19,80	23,70	25,60	36,90	7,50	8,80	14,70	21,90	19,50
Maximum		16,70	27,30	32,30	38,00	49,00	16,50	17,40	20,90	32,90	32,80

		L5TPW	L5IFLCR	L5IFLCA	L5IFRCR	L5IFRCA	FMM16	FMM7	HLM1	HCM7	FHBM18
N	Valid	15	27	27	27	27	21	21	29	30	29
Mean		84,48	6,95	11,31	7,13	11,28	35,84	31,05	304,28	58,67	43,85
Median		82,40	6,90	11,20	7,20	11,20	36,20	30,90	305,00	58,00	43,80
Mode		82,40	5,80	11,00	5,30	10,50	38,30	28,30[a]	308,00	59,00	43,60[a]
Std. Deviation		10,56	1,14	1,64	1,28	1,58	3,49	2,76	21,16	5,01	3,17
Minimum		62,30	5,30	7,30	4,40	8,70	30,10	27,00	266,00	50,00	37,20
Maximum		100,10	8,90	14,80	8,90	15,10	40,70	37,50	356,00	74,00	51,20

		FLM1	FCM8	BIWM2
N	Valid	26	29	25
Mean		426,54	82,66	282,16
Median		429,50	83,00	280,00
Mode		436,00	85,00	270,00
Std. Deviation		25,27	6,09	15,69
Minimum		373,00	71,00	248,00
Maximum		477,00	95,00	318,00

a. Multiple modes exist. The smallest value is shown

4. Sexual dimorphism of all variables in modern samples (means of modern samples, percentage-difference, t-values)

Variable	Mean males	Mean females	males > females (%)	t
C3 dorsal vertebral body height dorsal	14.6	12.8	11.03	**5.31**
C3 ventral vertebral body height	14.1	12.5	10.62	**5.57**
C3 vertebral body sagittal diameter	16.2	14.7	7.44	**4.01**
C3 vertebral body transverse diameter	19.3	18.1	3.97	*2.14*
C3 left pedicle height	7.3	6.2	13.68	**4.33**
C3 right pedicle height	7.3	6.3	12.08	**3.90**
C3 spinal canal sagittal diameter	15.9	15.4	2.35	1.28
C3 spinal canal transverse diameter	24.5	23.9	4.20	1.66
C3 spinous process lengtt	16.9	16.0	17.74	0.60
C3 transverse process width	56.1	51.9	8.81	**3.51**
C3 left cranial intervertebral foramen width	6.8	6.7	1.15	0.61
C3 left caudal intervertebral foramen width	8.2	8.3	-0.90	0.18 *
C3 right cranial intervertebral foramen width	6.5	6.6	-1.76	0.48
C3 right caudal intervertebral foramen width	8.2	8.1	-2.48	0.21 *
C7 dorsal vertebral body height	15.2	13.8	8.69	**4.48**
C7 ventral vertebral body height	13.7	12.8	7.29	*2.65*
C7 vertebral body sagittal diameter	17.7	16.0	9.14	**4.17**
C7 vertebral body transverse diameter	26.6	24.4	6.33	**4.25**
C7 left pedicle height	7.5	6.5	8.73	**4.29**
C7 right pedicle height	7.5	6.6	8.30	**3.57**
C7 sagittal diameter spinal canal	15.1	14.5	3.80	1.65
C7 transverse diameter spinal canal	26.1	25.7	3.09	0.93
C7 spinous process length	31.5	26.1	13.04	**4.72**
C7 transverse process width	66.2	52.9	17.64	1.29
C7 left cranial intervertebral foramen width	6.3	6.6	-3.30	1.35 *
C7 left caudal intervertebral foramen width	10.1	10.0	1.87	0.26
C7 right cranial intervertebral foramen width	6.6	6.8	-0.90	0.99 *
C7 right caudal intervertebral foramen width	10.1	9.8	3.18	0.96
TH1 dorsal vertebral body height	17.3	15.7	8.97	**4.59**
TH1 ventral vertebral body height	16.0	14.5	9.11	**4.67**
TH1 sagittal diameter vertebral body	17.8	16.0	8.75	**3.90**
TH1 transverse diameter vertebral body	28.9	26.1	7.96	**4.83**
TH1 left pedicle height	9.3	8.4	10.20	**3.06**
TH1 right pedicle height	9.1	8.3	9.22	**3.00**
TH1 spinal canal sagittal diameter	15.8	15.3	3.27	1.52
TH1 spinal canal transverse diameter	23.3	22.2	5.16	*2.50*
TH1 spinous process length	33.2	29.1	13.01	**3.66**
TH1 transverse process width	79.1	72.5	9.07	**5.72**
TH1 left cranial intervertebral foramen width	6.6	6.6	0.42	0.20
TH1 left caudal intervertebral foramen width	10.9	10.3	0.94	1.53
TH1 right cranial intervertebral foramen width	6.5	6.7	-0.70	0.97 *
TH1 right caudal intervertebral foramen width	10.6	10.4	0.76	0.38
TH6 dorsal vertebral body height	21.0	19.8	8.44	**3.35**
TH6 ventral vertebral body height	19.0	17.7	7.79	**3.56**
TH6 sagittal diameter vertebral body	26.3	23.6	10.59	**4.46**
TH6 transverse diameter vertebral body	27.9	24.6	10.98	**6.34**
TH6 left pedicle height	12.2	10.5	13.22	**5.33**
TH6 right pedicle height	12.6	10.8	13.86	**6.19**
TH6 spinal canal sagittal diameter	16.7	16.2	2.45	1.76
TH6 spinal canal transverse diameter	17.7	16.9	4.33	1.89
TH6 spinous process length	18.7	17.0	17.81	0.78
TH6 transverse process width	65.5	60.9	8.28	**3.74**
TH6 left caudal intervertebral foramen width	13.3	12.4	-0.81	1.85
TH6 right caudal intervertebral foramen width	12.7	11.5	0.71	**3.01**
TH10 dorsal vertebral body height	23.8	22.1	8.20	**5.01**
TH10 ventral vertebral body height	22.2	21.4	5.96	1.92
TH10 vertebral body sagittal diameter	31.3	27.3	12.42	**5.31**
TH10 vertebral body transverse diameter	34.7	31.0	11.07	**5.39**
TH10 left pedicle height	15.7	14.3	10.09	**3.77**
TH10 right pedicle height	15.8	14.3	9.32	**4.01**
TH10 spinal canal sagittal diameter	16.4	16.4	2.91	0.01
TH10 spinal canal transverse diameter	18.6	17.9	5.67	1.76
TH10 spinous process length	30.4	26.1	9.68	*2.83*
TH10 transverse process width	63.0	58.1	9.33	**3.59**
TH10 left caudal intervertebral foramen width	13.1	12.7	0.87	1.10
TH10 right caudal intervertebral foramen width	12.9	12.6	1.32	0.83
L1 dorsal vertebral body height	27.9	26.4	6.08	**3.16**
L1 ventral vertebral body height	25.5	25.0	4.03	0.94
L1 vertebral body sagittal diameter	32.9	28.2	12.85	**6.64**
L1 vertebral body transverse diameter	41.0	35.9	11.84	**6.70**
L1 left pedicle height	16.4	14.4	8.75	**5.89**
L1 right pedicle height	16.5	14.6	9.22	**4.68**
L1 spinal canal sagittal diameter	18.2	18.4	0.33	0.42 *
L1 spinal canal transverse diameter	24.4	23.2	4.96	*2.55*
L1 spinous process length	32.3	29.2	12.32	1.34

L1 transverse process width	75.1	68.3	11.49	*2.11*
L1 left cranial intervertebral foramen width	8.6	9.1	-7.27	1.80 *
L1 left caudal intervertebral foramen width	13.1	13.6	-3.43	1.05 *
L1 right cranial intervertebral foramen width	8.9	9.5	-5.92	1.68 *
L1 right caudal intervertebral foramen width	13.0	13.4	-2.58	1.04 *
L5 dorsal vertebral body height	24.1	23.6	4.16	1.04
L5 ventral vertebral body height	28.9	28.1	5.61	1.43
L5 vertebral body sagittal diameter	34.5	30.4	7.54	**5.40**
L5 vertebral body transverse diameter	47.7	42.6	7.75	**5.07**
L5 left pedicle height	13.9	12.7	8.56	*2.54*
L5 right pedicle height	14.5	13.3	7.00	*2.51*
L5 spinal canal sagittal diameter	17.7	17.7	0.07	0.05
L5 spinal canal transverse diameter	26.3	26.5	0.87	0.34 *
L5 spinous processus length	29.9	26.7	7.79	*2.05*
L5 transverse process width	91.5	84.5	8.47	*2.21*
L5 left cranial intervertebral foramen width	6.5	6.9	-5.60	1.56 *
L5 left caudal intervertebral foramen width	10.1	11.3	-5.40	*2.53* *
L5 right cranial intervertebral foramen width	6.3	7.1	-6.57	*2.69* *
L5 right caudal intervertebral foramen width	9.8	11.3	-6.60	**3.61** *
foramen magnum sagittal diameter	37.3	35.8	3.97	1.65
foramen magnum transverse diameter	32.4	31.0	6.35	1.86
humerus length	325.5	304.3	8.28	**4.67**
humerus circumference	67.3	58.7	12.84	**6.89**
femoral head width	49.4	43.9	11.70	**7.23**
femur length	453.4	426.5	7.20	**4.21**
femur circumference	89.4	82.7	10.90	**4.35**
bi-iliac width	289.8	282.2	4.00	1.68

*: bigger mean value in females than males
italic: significant ($p<0.05$) before Bonferroni's correction
Bold: significant ($p<0.05$) after Bonferroni's correction

5. Side differences of variables in modern samples (means, t-values)

Variable	Males		Females	
	Mean (mm)	t	Mean (mm)	t
C3 left pedicle height	7.3		6.2	
C3 right pedicle height	7.3	0.27	6.3	0.12
C3 left cranial intervertebral foramen width	6.8		6.7	
C3 right cranial intervertebral foramen width	6.5	1.58	6.6	0.20
C3 left caudal intervertebral foramen width	8.2		8.3	
C3 right caudal intervertebral foramen width	8.2	0.04	8.1	0.40
C7 left pedicle height	7.5		6.5	
C7 right pedicle height	7.5	0.01	6.6	0.43
C7 left cranial intervertebral foramen width	6.3		6.6	
C7 right cranial intervertebral foramen width	6.6	1.28	6.8	0.64
C7 left caudal intervertebral foramen width	10.1		10.0	
C7 right caudal intervertebral foramen width	10.1	0.15	9.8	0.45
TH1 left pedicle height	9.3		8.4	
TH1 righ pedicle height	9.1	0.68	8.3	0.34
TH1 left cranial intervertebral foramen width	6.6		6.6	
TH1 right cranial intervertebral foramen width	6.5	0.28	6.7	0.45
TH1 left caudal intervertebral foramen width	10.9		10.3	
TH1 right caudal intervertebral foramen width	10.6	0.93	10.4	0.22
TH6 left pedicle height	12.2		10.5	
TH6 right pedicle height	12.6	1.60	10.8	0.77
TH6 left caudal intervertebral foramen width	13.3		12.4	
TH6 right caudal intervertebral foramen width	12.7	1.79	11.5	1.85
TH10 left pedicle height	15.7		14.3	
TH10 right pedicle height	15.8	0.39	14.3	0.17
TH10 left caudal intervertebral foramen width	13.1		12.7	
TH10 right caudal intervertebral foramen width	12.9	0.28	12.6	0.15
L1 left pedicle height	16.4		14.4	
L1 right pedicle height	16.5	0.27	14.6	0.70
L1 left cranial intervertebral foramen width	8.6		9.1	
L1 right cranial intervertebral foramen width	8.9	1.08	9.5	1.02
L1 left caudal intervertebral foramen width	13.1		13.6	
L1 right caudal intervertebral foramen width	13.0	0.12	13.4	0.33
L5 left pedicle height	13.9		12.7	
L5 right pedicle height	14.5	1.58	13.3	1.08
L5 left cranial intervertebral foramen width	6.5		6.9	
L5 right cranial intervertebral foramen width	6.3	0.85	7.1	0.55
L5 left caudal intervertebral foramen width	10.1		11.3	
L5 right caudal intervertebral foramen width	9.8	0.64	11.3	0.07

6. Correlations of variables with individual age in modern samples

Modern - males

		AGE
C3M2	Pearson Correlation	,341*
	N	38
C3M1	Pearson Correlation	,285
	N	38
C3M6	Pearson Correlation	,682**
	N	36
C3M9	Pearson Correlation	,623**
	N	37
C3PHL	Pearson Correlation	,500**
	N	35
C3PHR	Pearson Correlation	,539**
	N	33
C3M10	Pearson Correlation	-,127
	N	34
C3M11	Pearson Correlation	,345*
	N	38
C3SPL	Pearson Correlation	,584
	N	11
C3TPW	Pearson Correlation	,442*
	N	22
C3IFLCR	Pearson Correlation	-,219
	N	37
C3IFLCA	Pearson Correlation	-,037
	N	35
C3IFRCR	Pearson Correlation	-,122
	N	34
C3IFRCA	Pearson Correlation	,011
	N	35
C7M2	Pearson Correlation	,227
	N	38
C7M1	Pearson Correlation	,242
	N	37
C7M6	Pearson Correlation	,627**
	N	36
C7M9	Pearson Correlation	,451**
	N	36
C7PHL	Pearson Correlation	,120
	N	36
C7PHR	Pearson Correlation	,231
	N	38
C7M10	Pearson Correlation	,004
	N	38
C7M11	Pearson Correlation	-,021
	N	38
C7SPL	Pearson Correlation	,150
	N	23
C7TPW	Pearson Correlation	,837*
	N	7
C7IFLCR	Pearson Correlation	-,251
	N	35
C7IFLCA	Pearson Correlation	,158
	N	38
C7IFRCR	Pearson Correlation	-,262
	N	35
C7IFRCA	Pearson Correlation	,136
	N	37

		AGE
T1M2	Pearson Correlation	,221
	N	40
T1M1	Pearson Correlation	,138
	N	38
T1M6	Pearson Correlation	,708**
	N	34
T1M9	Pearson Correlation	,435**
	N	38
T1PHL	Pearson Correlation	,393*
	N	40
T1PHR	Pearson Correlation	,438**
	N	39
T1M10	Pearson Correlation	,206
	N	38
T1M11	Pearson Correlation	,302
	N	40
T1SPL	Pearson Correlation	,093
	N	20
T1TPW	Pearson Correlation	,527**
	N	35
T1IFLCR	Pearson Correlation	-,083
	N	38
T1IFLCA	Pearson Correlation	,118
	N	39
T1IFRCR	Pearson Correlation	-,051
	N	35
T1IFRCA	Pearson Correlation	,163
	N	39
T6M2	Pearson Correlation	,288
	N	36
T6M1	Pearson Correlation	,133
	N	35
T6M6	Pearson Correlation	,483**
	N	34
T6M9	Pearson Correlation	,253
	N	36
T6PHL	Pearson Correlation	,424*
	N	35
T6PHR	Pearson Correlation	,508**
	N	36
T6M10	Pearson Correlation	,189
	N	34
T6M11	Pearson Correlation	-,061
	N	36
T6SPL	Pearson Correlation	-,404
	N	13
T6TPW	Pearson Correlation	,250
	N	27
T6IFLCA	Pearson Correlation	,160
	N	32
T6IFRCA	Pearson Correlation	,108
	N	32
T10M2	Pearson Correlation	,216
	N	38
T10M1	Pearson Correlation	,056
	N	34

		AGE
T10M6	Pearson Correlation	,371*
	N	31
T10M9	Pearson Correlation	,555**
	N	39
T10PHL	Pearson Correlation	,160
	N	40
T10PHR	Pearson Correlation	,220
	N	38
T10M10	Pearson Correlation	,267
	N	38
T10M11	Pearson Correlation	,077
	N	40
T10SPL	Pearson Correlation	,318
	N	11
T10TPW	Pearson Correlation	,288
	N	24
T10IFLCA	Pearson Correlation	,031
	N	38
T10IFRCA	Pearson Correlation	-,013
	N	37
L1M2	Pearson Correlation	,157
	N	36
L1M1	Pearson Correlation	,305
	N	36
L1M6	Pearson Correlation	,189
	N	33
L1M9	Pearson Correlation	,435**
	N	37
L1PHL	Pearson Correlation	,340*
	N	35
L1PHR	Pearson Correlation	,470**
	N	36
L1M10	Pearson Correlation	,087
	N	34
L1M11	Pearson Correlation	,090
	N	35
L1SPL	Pearson Correlation	,396
	N	8
L1TPW	Pearson Correlation	-,070
	N	16
L1IFLCR	Pearson Correlation	-,043
	N	34
L1IFLCA	Pearson Correlation	,074
	N	34
L1IFRCR	Pearson Correlation	,120
	N	32
L1IFRCA	Pearson Correlation	,218
	N	34
L5M2	Pearson Correlation	,206
	N	36
L5M1	Pearson Correlation	,181
	N	37
L5M6	Pearson Correlation	,452**
	N	32
L5M9	Pearson Correlation	,616**
	N	38

		AGE
L5PHL	Pearson Correlation	,250
	N	38
L5PHR	Pearson Correlation	,325*
	N	37
L5M10	Pearson Correlation	-,083
	N	35
L5M11	Pearson Correlation	,162
	N	38
L5SPL	Pearson Correlation	,453
	N	11
L5TPW	Pearson Correlation	,248
	N	18
L5IFLCR	Pearson Correlation	,446**
	N	38
L5IFLCA	Pearson Correlation	,088
	N	37
L5IFRCR	Pearson Correlation	,262
	N	35
L5IFRCA	Pearson Correlation	-,149
	N	36
FMM16	Pearson Correlation	,259
	N	28
FMM7	Pearson Correlation	-,070
	N	28
HLM1	Pearson Correlation	,227
	N	36
HCM7	Pearson Correlation	,524**
	N	40

		AGE
FHM18	Pearson Correlation	,271
	N	39
FLM1	Pearson Correlation	-,121
	N	36
FCM8	Pearson Correlation	,421**
	N	39
BIWM2	Pearson Correlation	,307
	N	24

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Modern - females

		AGE
C3M2	Pearson Correlation	-,064
	N	26
C3M1	Pearson Correlation	-,287
	N	24
C3M6	Pearson Correlation	,293
	N	25
C3M9	Pearson Correlation	,397*
	N	25
C3PHL	Pearson Correlation	,165
	N	27
C3PHR	Pearson Correlation	,171
	N	26
C3M10	Pearson Correlation	,074
	N	24
C3M11	Pearson Correlation	-,167
	N	26
C3SPL	Pearson Correlation	,645
	N	9
C3TPW	Pearson Correlation	-,535*
	N	17
C3IFLCR	Pearson Correlation	,126
	N	26
C3IFLCA	Pearson Correlation	-,046
	N	27
C3IFRCR	Pearson Correlation	-,008
	N	26
C3IFRCA	Pearson Correlation	,017
	N	26
C7M2	Pearson Correlation	-,106
	N	26
C7M1	Pearson Correlation	-,206
	N	25
C7M6	Pearson Correlation	,209
	N	26
C7M9	Pearson Correlation	,088
	N	26
C7PHL	Pearson Correlation	,132
	N	26
C7PHR	Pearson Correlation	,399*
	N	27
C7M10	Pearson Correlation	,322
	N	26
C7M11	Pearson Correlation	-,044
	N	27
C7SPL	Pearson Correlation	-,397
	N	14
C7TPW	Pearson Correlation	-,575
	N	6
C7IFLCR	Pearson Correlation	-,224
	N	26
C7IFLCA	Pearson Correlation	,299
	N	26
C7IFRCR	Pearson Correlation	,105
	N	25
C7IFRCA	Pearson Correlation	,243
	N	24

		AGE
T1M2	Pearson Correlation	-,148
	N	28
T1M1	Pearson Correlation	-,236
	N	27
T1M6	Pearson Correlation	,013
	N	27
T1M9	Pearson Correlation	,092
	N	28
T1PHL	Pearson Correlation	,137
	N	28
T1TPHR	Pearson Correlation	,209
	N	28
T1M10	Pearson Correlation	,299
	N	28
T1M11	Pearson Correlation	,214
	N	28
T1SPL	Pearson Correlation	-,383
	N	13
T1TPW	Pearson Correlation	,077
	N	25
T1IFLCR	Pearson Correlation	,056
	N	28
T1IFLCA	Pearson Correlation	,194
	N	27
T1IFRCR	Pearson Correlation	,027
	N	28
T1IFRCA	Pearson Correlation	,306
	N	27
T6M2	Pearson Correlation	,037
	N	26
T6M1	Pearson Correlation	-,036
	N	27
T6M6	Pearson Correlation	,176
	N	27
T6M9	Pearson Correlation	-,234
	N	28
T6PHL	Pearson Correlation	-,210
	N	27
T6PHR	Pearson Correlation	,065
	N	27
T6M10	Pearson Correlation	,382
	N	26
T6M11	Pearson Correlation	,132
	N	27
T6SPL	Pearson Correlation	,389
	N	11
T6TPW	Pearson Correlation	,237
	N	22
T6IFLCA	Pearson Correlation	,106
	N	24
T6IFRCA	Pearson Correlation	,145
	N	25
T10M2	Pearson Correlation	-,230
	N	28
T10M1	Pearson Correlation	-,244
	N	28

		AGE
T10M6	Pearson Correlation	-,055
	N	26
T10M9	Pearson Correlation	-,066
	N	29
T10PHL	Pearson Correlation	,250
	N	28
T10PHR	Pearson Correlation	,129
	N	27
T10M10	Pearson Correlation	,288
	N	27
T10M11	Pearson Correlation	,066
	N	28
T10SPL	Pearson Correlation	-,074
	N	13
T10TPW	Pearson Correlation	,186
	N	22
T10IFLCA	Pearson Correlation	,117
	N	28
T10IFRCA	Pearson Correlation	,187
	N	27
L1M2	Pearson Correlation	-,086
	N	27
L1M1	Pearson Correlation	-,338
	N	25
L1M6	Pearson Correlation	,213
	N	25
L1M9	Pearson Correlation	-,096
	N	28
L1PHL	Pearson Correlation	,240
	N	27
L1PHR	Pearson Correlation	,223
	N	28
L1M10	Pearson Correlation	,031
	N	28
L1M11	Pearson Correlation	,331
	N	28
L1SPL	Pearson Correlation	-,106
	N	13
L1TPW	Pearson Correlation	-,060
	N	15
L1IFLCR	Pearson Correlation	,172
	N	28
L1IFLCA	Pearson Correlation	-,050
	N	27
L1IFRCR	Pearson Correlation	,261
	N	27
L1IFRCA	Pearson Correlation	,130
	N	27
L5M2	Pearson Correlation	-,204
	N	26
L5M1	Pearson Correlation	-,479*
	N	24
L5M6	Pearson Correlation	,071
	N	23
L5M9	Pearson Correlation	,378
	N	27

		AGE
L5PHL	Pearson Correlation	,228
	N	26
L5PHR	Pearson Correlation	,165
	N	26
L5M10	Pearson Correlation	,086
	N	25
L5M11	Pearson Correlation	,129
	N	27
L5SPL	Pearson Correlation	-,043
	N	13
L5TPW	Pearson Correlation	-,153
	N	15
L5IFLCR	Pearson Correlation	,168
	N	27
L5IFLCA	Pearson Correlation	,214
	N	27
L5IFRCR	Pearson Correlation	,037
	N	27
L5IFRCA	Pearson Correlation	,135
	N	27
FMM16	Pearson Correlation	,090
	N	21
FMM7	Pearson Correlation	,138
	N	21
HLM1	Pearson Correlation	-,343
	N	29
HCM7	Pearson Correlation	-,346
	N	30
FHM18	Pearson Correlation	-,199
	N	29

		AGE
FLM1	Pearson Correlation	-,474*
	N	26
FCM8	Pearson Correlation	-,359
	N	29
BIWM2	Pearson Correlation	,141
	N	25

*. Correlation is significant at the 0,05 level (2-tailed).

7. Correlations of variables with major age groups in non-modern samples

Non-modern - males

		AGEGROUP
C3M2	Pearson Correlation	,162
	N	87
C3M1	Pearson Correlation	,182
	N	86
C3M6	Pearson Correlation	,423**
	N	83
C3M9	Pearson Correlation	-,070
	N	80
C3PHL	Pearson Correlation	,240*
	N	82
C3PHR	Pearson Correlation	,262*
	N	82
C3M10	Pearson Correlation	-,062
	N	73
C3M11	Pearson Correlation	-,091
	N	81
C3SPL	Pearson Correlation	-,028
	N	27
C3TPW	Pearson Correlation	,022
	N	50
C3IFLCR	Pearson Correlation	-,125
	N	81
C3IFLCA	Pearson Correlation	-,017
	N	81
C3IFRCR	Pearson Correlation	-,151
	N	85
C3IFRCA	Pearson Correlation	-,070
	N	84
C7M2	Pearson Correlation	-,019
	N	90
C7M1	Pearson Correlation	,035
	N	90
C7M6	Pearson Correlation	,594**
	N	92
C7M9	Pearson Correlation	,356**
	N	90
C7PHL	Pearson Correlation	,098
	N	85
C7PHR	Pearson Correlation	,069
	N	85
C7M10	Pearson Correlation	-,053
	N	83
C7M11	Pearson Correlation	,174
	N	90
C7SPL	Pearson Correlation	,122
	N	52
C7TPW	Pearson Correlation	,052
	N	26
C7IFLCR	Pearson Correlation	-,112
	N	86
C7IFLCA	Pearson Correlation	-,120
	N	83
C7IFRCR	Pearson Correlation	-,203
	N	87
C7IFRCA	Pearson Correlation	-,111
	N	86

		AGEGROUP
T1M2	Pearson Correlation	,136
	N	94
T1M1	Pearson Correlation	,201
	N	93
T1M6	Pearson Correlation	,468**
	N	90
T1M9	Pearson Correlation	,218*
	N	93
T1PHL	Pearson Correlation	,217*
	N	88
T1PHR	Pearson Correlation	,223*
	N	89
T1M10	Pearson Correlation	,010
	N	84
T1M11	Pearson Correlation	,031
	N	85
T1SPL	Pearson Correlation	,204
	N	57
T1TPW	Pearson Correlation	,269*
	N	67
T1IFLCR	Pearson Correlation	-,178
	N	86
T1IFLCA	Pearson Correlation	-,055
	N	85
T1IFRCR	Pearson Correlation	-,188
	N	82
T1IFRCA	Pearson Correlation	-,120
	N	82
T6M2	Pearson Correlation	,400**
	N	88
T6M1	Pearson Correlation	,180
	N	85
T6M6	Pearson Correlation	,469**
	N	82
T6M9	Pearson Correlation	,338**
	N	85
T6PHL	Pearson Correlation	,219*
	N	83
T6PHR	Pearson Correlation	,256*
	N	85
T6M10	Pearson Correlation	,003
	N	74
T6M11	Pearson Correlation	,080
	N	84
T6SPL	Pearson Correlation	-,150
	N	27
T6TPW	Pearson Correlation	,349*
	N	43
T6IFLCA	Pearson Correlation	,032
	N	69
T6IFRCA	Pearson Correlation	-,174
	N	67
T10M2	Pearson Correlation	,215*
	N	97
T10M1	Pearson Correlation	,167
	N	95

		AGEGROUP
T10M6	Pearson Correlation	.468**
	N	93
T10M9	Pearson Correlation	.366**
	N	96
T10PHL	Pearson Correlation	.185
	N	92
T10PHR	Pearson Correlation	.255*
	N	92
T10M10	Pearson Correlation	-.004
	N	89
T10M11	Pearson Correlation	.037
	N	93
T10SPL	Pearson Correlation	.258
	N	42
T10TPW	Pearson Correlation	.231
	N	57
T10IFLCA	Pearson Correlation	-.163
	N	86
T10IFRCA	Pearson Correlation	-.087
	N	87
L1M2	Pearson Correlation	.118
	N	111
L1M1	Pearson Correlation	.150
	N	105
L1M6	Pearson Correlation	.319**
	N	99
L1M9	Pearson Correlation	.299**
	N	110
L1PHL	Pearson Correlation	.191
	N	106
L1PHR	Pearson Correlation	.140
	N	107
L1M10	Pearson Correlation	.060
	N	96
L1M11	Pearson Correlation	.208*
	N	102
L1SPL	Pearson Correlation	.103
	N	46
L1TPW	Pearson Correlation	.293
	N	36
L1IFLCR	Pearson Correlation	.079
	N	99
L1IFLCA	Pearson Correlation	-.012
	N	93
L1IFRCR	Pearson Correlation	-.051
	N	95
L1IFRCA	Pearson Correlation	.081
	N	92
L5M2	Pearson Correlation	.186
	N	100
L5M1	Pearson Correlation	.240*
	N	102
L5M6	Pearson Correlation	.252*
	N	100
L5M9	Pearson Correlation	.277**
	N	105

		AGEGROUP
L5PHL	Pearson Correlation	.198*
	N	101
L5PHR	Pearson Correlation	.221*
	N	98
L5M10	Pearson Correlation	.133
	N	86
L5M11	Pearson Correlation	.170
	N	92
L5SPL	Pearson Correlation	-.311*
	N	44
L5TPW	Pearson Correlation	.051
	N	40
L5IFLCR	Pearson Correlation	-.137
	N	97
L5IFLCA	Pearson Correlation	-.075
	N	87
L5IFRCR	Pearson Correlation	.018
	N	93
L5IFRCA	Pearson Correlation	-.023
	N	84
FMM18	Pearson Correlation	.231
	N	28
FMM7	Pearson Correlation	.017
	N	25
HLM1	Pearson Correlation	.292**
	N	90
HCM7	Pearson Correlation	.219*
	N	117
FHBM18	Pearson Correlation	.376**
	N	115

		AGEGROUP
FLM1	Pearson Correlation	.329**
	N	94
FCM8	Pearson Correlation	.275**
	N	117
BIWM2	Pearson Correlation	.165
	N	39

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Non-modern - females

		AGEGROUP
C3M2	Pearson Correlation	,079
	N	102
C3M1	Pearson Correlation	,153
	N	101
C3M6	Pearson Correlation	,421**
	N	99
C3M9	Pearson Correlation	-,026
	N	98
C3PHL	Pearson Correlation	,146
	N	97
C3PHR	Pearson Correlation	,292**
	N	98
C3M10	Pearson Correlation	-,215
	N	77
C3M11	Pearson Correlation	,035
	N	97
C3SPL	Pearson Correlation	,374*
	N	36
C3TPW	Pearson Correlation	,081
	N	53
C3IFLCR	Pearson Correlation	-,220*
	N	95
C3IFLCA	Pearson Correlation	-,189
	N	96
C3IFRCR	Pearson Correlation	-,192
	N	97
C3IFRCA	Pearson Correlation	-,183
	N	97
C7M2	Pearson Correlation	,075
	N	100
C7M1	Pearson Correlation	-,045
	N	101
C7M6	Pearson Correlation	,422**
	N	99
C7M9	Pearson Correlation	,198*
	N	99
C7PHL	Pearson Correlation	,116
	N	97
C7PHR	Pearson Correlation	,113
	N	101
C7M10	Pearson Correlation	,026
	N	93
C7M11	Pearson Correlation	,069
	N	95
C7SPL	Pearson Correlation	-,199
	N	55
C7TPW	Pearson Correlation	,247
	N	27
C7IFLCR	Pearson Correlation	-,331**
	N	91
C7IFLCA	Pearson Correlation	-,072
	N	88
C7IFRCR	Pearson Correlation	-,232*
	N	93
C7IFRCA	Pearson Correlation	-,226*
	N	89

		AGEGROUP
T1M2	Pearson Correlation	,172
	N	98
T1M1	Pearson Correlation	-,029
	N	96
T1M6	Pearson Correlation	,354**
	N	92
T1M9	Pearson Correlation	,240*
	N	95
T1PHL	Pearson Correlation	,174
	N	93
T1PHR	Pearson Correlation	,120
	N	98
T1M10	Pearson Correlation	,094
	N	85
T1M11	Pearson Correlation	,179
	N	92
T1SPL	Pearson Correlation	-,217
	N	40
T1TPW	Pearson Correlation	,022
	N	64
T1IFLCR	Pearson Correlation	-,156
	N	88
T1IFLCA	Pearson Correlation	-,082
	N	86
T1IFRCR	Pearson Correlation	-,226*
	N	90
T1IFRCA	Pearson Correlation	-,036
	N	87
T6M2	Pearson Correlation	,071
	N	95
T6M1	Pearson Correlation	-,030
	N	95
T6M6	Pearson Correlation	,391**
	N	93
T6M9	Pearson Correlation	,153
	N	96
T6PHL	Pearson Correlation	,156
	N	91
T6PHR	Pearson Correlation	,150
	N	92
T6M10	Pearson Correlation	-,051
	N	82
T6M11	Pearson Correlation	,102
	N	91
T6SPL	Pearson Correlation	-,239
	N	32
T6TPW	Pearson Correlation	,241
	N	65
T6IFLCA	Pearson Correlation	,016
	N	74
T6IFRCA	Pearson Correlation	,015
	N	72
T10M2	Pearson Correlation	,060
	N	105
T10M1	Pearson Correlation	-,014
	N	102

		AGEGROUP
T10M6	Pearson Correlation	,092
	N	104
T10M9	Pearson Correlation	,159
	N	105
T10PHL	Pearson Correlation	,127
	N	101
T10PHR	Pearson Correlation	,039
	N	103
T10M10	Pearson Correlation	,052
	N	95
T10M11	Pearson Correlation	-,036
	N	99
T10SPL	Pearson Correlation	,100
	N	44
T10TPW	Pearson Correlation	,053
	N	67
T10IFLCA	Pearson Correlation	,155
	N	90
T10IFRCA	Pearson Correlation	,083
	N	92
L1M2	Pearson Correlation	-,127
	N	112
L1M1	Pearson Correlation	-,041
	N	109
L1M6	Pearson Correlation	-,030
	N	105
L1M9	Pearson Correlation	,087
	N	108
L1PHL	Pearson Correlation	,058
	N	108
L1PHR	Pearson Correlation	,052
	N	112
L1M10	Pearson Correlation	,045
	N	97
L1M11	Pearson Correlation	,187
	N	110
L1SPL	Pearson Correlation	,154
	N	43
L1TPW	Pearson Correlation	-,284
	N	42
L1IFLCR	Pearson Correlation	,063
	N	92
L1IFLCA	Pearson Correlation	,022
	N	92
L1IFRCR	Pearson Correlation	,035
	N	87
L1IFRCA	Pearson Correlation	,069
	N	94
L5M2	Pearson Correlation	,116
	N	110
L5M1	Pearson Correlation	,000
	N	106
L5M6	Pearson Correlation	,036
	N	106
L5M9	Pearson Correlation	,238*
	N	113

		AGEGROUP
L5PHL	Pearson Correlation	,079
	N	104
L5PHR	Pearson Correlation	-,034
	N	106
L5M10	Pearson Correlation	-,019
	N	92
L5M11	Pearson Correlation	,117
	N	101
L5SPL	Pearson Correlation	,141
	N	46
L5TPW	Pearson Correlation	,008
	N	55
L5IFLCR	Pearson Correlation	-,022
	N	103
L5IFLCA	Pearson Correlation	-,084
	N	98
L5IFRCR	Pearson Correlation	-,110
	N	100
L5IFRCA	Pearson Correlation	-,202*
	N	98
FMM16	Pearson Correlation	-,121
	N	29
FMM7	Pearson Correlation	-,063
	N	30
HLM1	Pearson Correlation	-,042
	N	92
HCM7	Pearson Correlation	,006
	N	118
FHBM18	Pearson Correlation	,153
	N	126

		AGEGROUP
FLM1	Pearson Correlation	-,064
	N	104
FCM8	Pearson Correlation	,220*
	N	122
BIWM2	Pearson Correlation	,158
	N	52

**. Correlation is significant at the 0,01 level (2-tailed).

*. Correlation is significant at the 0,05 level (2-tailed).

8. Correlations of variables with major age groups separately for major time groups

Neolithic / Bronze Age - males

		AGEGROUP
C3M2	Pearson Correlation	,241
	N	24
C3M1	Pearson Correlation	,196
	N	24
C3M6	Pearson Correlation	,459*
	N	24
C3M9	Pearson Correlation	-,172
	N	23
C3PHL	Pearson Correlation	,332
	N	22
C3PHR	Pearson Correlation	,250
	N	20
C3M10	Pearson Correlation	-,148
	N	20
C3M11	Pearson Correlation	-,486*
	N	21
C3TPW	Pearson Correlation	-,315
	N	15
C3IFLCR	Pearson Correlation	-,364
	N	21
C3IFLCA	Pearson Correlation	-,319
	N	21
C3IFRCR	Pearson Correlation	-,342
	N	22
C3IFRCA	Pearson Correlation	-,486*
	N	22
C7M2	Pearson Correlation	,047
	N	22
C7M1	Pearson Correlation	,125
	N	23
C7M6	Pearson Correlation	,560**
	N	24
C7M9	Pearson Correlation	,597**
	N	24
C7PHL	Pearson Correlation	,222
	N	21
C7PHR	Pearson Correlation	-,041
	N	22
C7M10	Pearson Correlation	-,205
	N	22
C7M11	Pearson Correlation	-,134
	N	22
C7SPL	Pearson Correlation	,320
	N	15
C7IFLCR	Pearson Correlation	-,450*
	N	22
C7IFLCA	Pearson Correlation	-,440*
	N	22
C7IFRCR	Pearson Correlation	-,219
	N	22
C7IFRCA	Pearson Correlation	-,467*
	N	22
T1M2	Pearson Correlation	,206
	N	24
T1M1	Pearson Correlation	,150
	N	23

		AGEGROUP
T1M6	Pearson Correlation	,459*
	N	22
T1M9	Pearson Correlation	-,074
	N	23
T1PHL	Pearson Correlation	,412
	N	22
T1PHR	Pearson Correlation	,157
	N	22
T1M10	Pearson Correlation	-,407
	N	23
T1M11	Pearson Correlation	-,476*
	N	23
T1SPL	Pearson Correlation	,214
	N	19
T1TPW	Pearson Correlation	,098
	N	15
T1IFLCR	Pearson Correlation	-,689**
	N	21
T1IFLCA	Pearson Correlation	-,493*
	N	22
T1IFRCR	Pearson Correlation	-,400
	N	21
T1IFRCA	Pearson Correlation	-,571**
	N	22
T6M2	Pearson Correlation	,318
	N	24
T6M1	Pearson Correlation	,311
	N	22
T6M6	Pearson Correlation	,542**
	N	22
T6M9	Pearson Correlation	,195
	N	23
T6PHL	Pearson Correlation	,119
	N	24
T6PHR	Pearson Correlation	,193
	N	24
T6M10	Pearson Correlation	-,415*
	N	23
T6M11	Pearson Correlation	-,345
	N	24
T6SPL	Pearson Correlation	-,304
	N	13
T6TPW	Pearson Correlation	,206
	N	13
T6IFLCA	Pearson Correlation	,140
	N	23
T6IFRCA	Pearson Correlation	-,011
	N	21
T10M2	Pearson Correlation	,123
	N	26
T10M1	Pearson Correlation	,179
	N	25
T10M6	Pearson Correlation	,320
	N	24
T10M9	Pearson Correlation	,088
	N	26

		AGEGROUP
T10PHL	Pearson Correlation	-.123
	N	25
T10PHR	Pearson Correlation	.022
	N	25
T10M10	Pearson Correlation	-.435*
	N	25
T10M11	Pearson Correlation	-.609**
	N	26
T10SPL	Pearson Correlation	-.003
	N	18
T10TPW	Pearson Correlation	.126
	N	17
T10IFLCA	Pearson Correlation	-.319
	N	26
T10IFRCA	Pearson Correlation	-.090
	N	26
L1M2	Pearson Correlation	.296
	N	29
L1M1	Pearson Correlation	.098
	N	28
L1M6	Pearson Correlation	.255
	N	27
L1M9	Pearson Correlation	.206
	N	29
L1PHL	Pearson Correlation	.259
	N	29
L1PHR	Pearson Correlation	.369*
	N	29
L1M10	Pearson Correlation	-.033
	N	27
L1M11	Pearson Correlation	-.064
	N	28
L1SPL	Pearson Correlation	-.105
	N	19
L1TPW	Pearson Correlation	.075
	N	9
L1IFLCR	Pearson Correlation	-.087
	N	28
L1IFLCA	Pearson Correlation	-.341
	N	27
L1IFRCR	Pearson Correlation	.063
	N	27
L1IFRCA	Pearson Correlation	-.209
	N	26
L5M2	Pearson Correlation	.000
	N	27
L5M1	Pearson Correlation	.229
	N	31
L5M6	Pearson Correlation	.367*
	N	31
L5M9	Pearson Correlation	-.003
	N	32
L5PHL	Pearson Correlation	-.024
	N	30
L5PHR	Pearson Correlation	.056
	N	27

		AGEGROUP
L5M10	Pearson Correlation	-.109
	N	27
L5M11	Pearson Correlation	-.183
	N	28
L5SPL	Pearson Correlation	-.471
	N	14
L5TPW	Pearson Correlation	-.310
	N	12
L5IFLCR	Pearson Correlation	-.403*
	N	30
L5IFLCA	Pearson Correlation	-.533**
	N	28
L5IFRCR	Pearson Correlation	-.179
	N	26
L5IFRCA	Pearson Correlation	-.488*
	N	26
FMM16	Pearson Correlation	.739*
	N	10
FMM7	Pearson Correlation	.700
	N	8
HLM1	Pearson Correlation	-.101
	N	24
HCM7	Pearson Correlation	-.069
	N	32
FHBM18	Pearson Correlation	.304
	N	35
FLM1	Pearson Correlation	.129
	N	26
FCM8	Pearson Correlation	.113
	N	34

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Neolithic / Bronze Age - females

		AGEGROUP
C3M2	Pearson Correlation	,038
	N	39
C3M1	Pearson Correlation	,167
	N	37
C3M6	Pearson Correlation	,605**
	N	38
C3M9	Pearson Correlation	,211
	N	37
C3PHL	Pearson Correlation	,244
	N	34
C3PHR	Pearson Correlation	,596**
	N	35
C3M10	Pearson Correlation	-,390*
	N	27
C3M11	Pearson Correlation	-,365*
	N	36
C3TPW	Pearson Correlation	,391
	N	17
C3IFLCR	Pearson Correlation	-,637**
	N	34
C3IFLCA	Pearson Correlation	-,437**
	N	35
C3IFRCR	Pearson Correlation	-,564**
	N	36
C3IFRCA	Pearson Correlation	-,460**
	N	36
C7M2	Pearson Correlation	-,171
	N	35
C7M1	Pearson Correlation	-,256
	N	35
C7M6	Pearson Correlation	,269
	N	34
C7M9	Pearson Correlation	-,001
	N	35
C7PHL	Pearson Correlation	,045
	N	33
C7PHR	Pearson Correlation	,232
	N	33
C7M10	Pearson Correlation	-,145
	N	33
C7M11	Pearson Correlation	-,038
	N	32
C7SPL	Pearson Correlation	-,208
	N	20
C7IFLCR	Pearson Correlation	-,473**
	N	33
C7IFLCA	Pearson Correlation	-,213
	N	31
C7IFRCR	Pearson Correlation	-,300
	N	34
C7IFRCA	Pearson Correlation	-,396*
	N	31
T1M2	Pearson Correlation	,057
	N	29
T1M1	Pearson Correlation	,049
	N	28

		AGEGROUP
T1M6	Pearson Correlation	,263
	N	28
T1M9	Pearson Correlation	,273
	N	29
T1PHL	Pearson Correlation	,062
	N	30
T1PHR	Pearson Correlation	,021
	N	29
T1M10	Pearson Correlation	,023
	N	29
T1M11	Pearson Correlation	-,112
	N	27
T1SPL	Pearson Correlation	,176
	N	15
T1TPW	Pearson Correlation	,253
	N	17
T1IFLCR	Pearson Correlation	-,392*
	N	27
T1IFLCA	Pearson Correlation	-,261
	N	27
T1IFRCR	Pearson Correlation	-,357
	N	25
T1IFRCA	Pearson Correlation	-,038
	N	27
T6M2	Pearson Correlation	,275
	N	28
T6M1	Pearson Correlation	,156
	N	29
T6M6	Pearson Correlation	,270
	N	28
T6M9	Pearson Correlation	,085
	N	29
T6PHL	Pearson Correlation	,321
	N	29
T6PHR	Pearson Correlation	,252
	N	29
T6M10	Pearson Correlation	-,097
	N	28
T6M11	Pearson Correlation	-,229
	N	29
T6SPL	Pearson Correlation	-,389
	N	14
T6TPW	Pearson Correlation	,232
	N	24
T6IFLCA	Pearson Correlation	-,451*
	N	24
T6IFRCA	Pearson Correlation	-,372
	N	25
T10M2	Pearson Correlation	,056
	N	38
T10M1	Pearson Correlation	,101
	N	36
T10M6	Pearson Correlation	,106
	N	37
T10M9	Pearson Correlation	-,089
	N	37

		AGEGROUP
T10PHL	Pearson Correlation	,011
	N	36
T10PHR	Pearson Correlation	,057
	N	38
T10M10	Pearson Correlation	,048
	N	37
T10M11	Pearson Correlation	-,351*
	N	36
T10SPL	Pearson Correlation	,148
	N	22
T10TPW	Pearson Correlation	,057
	N	26
T10IFLCA	Pearson Correlation	-,226
	N	35
T10IFRCA	Pearson Correlation	-,149
	N	37
L1M2	Pearson Correlation	,032
	N	41
L1M1	Pearson Correlation	,097
	N	39
L1M6	Pearson Correlation	-,009
	N	39
L1M9	Pearson Correlation	-,140
	N	39
L1PHL	Pearson Correlation	,150
	N	42
L1PHR	Pearson Correlation	,175
	N	41
L1M10	Pearson Correlation	,138
	N	39
L1M11	Pearson Correlation	,012
	N	41
L1SPL	Pearson Correlation	-,110
	N	21
L1TPW	Pearson Correlation	,272
	N	19
L1IFLCR	Pearson Correlation	-,233
	N	34
L1IFLCA	Pearson Correlation	-,012
	N	39
L1IFRCR	Pearson Correlation	-,162
	N	30
L1IFRCA	Pearson Correlation	,030
	N	38
L5M2	Pearson Correlation	,192
	N	42
L5M1	Pearson Correlation	-,095
	N	44
L5M6	Pearson Correlation	-,048
	N	44
L5M9	Pearson Correlation	,005
	N	46
L5PHL	Pearson Correlation	,161
	N	41
L5PHR	Pearson Correlation	-,040
	N	42

		AGEGROUP
L5M10	Pearson Correlation	-,017
	N	35
L5M11	Pearson Correlation	-,027
	N	40
L5SPL	Pearson Correlation	-,215
	N	22
L5TPW	Pearson Correlation	,079
	N	24
L5IFLCR	Pearson Correlation	,198
	N	39
L5IFLCA	Pearson Correlation	-,287
	N	39
L5IFRCR	Pearson Correlation	-,150
	N	39
L5IFRCA	Pearson Correlation	-,256
	N	40
FMM16	Pearson Correlation	. [a]
	N	12
FMM7	Pearson Correlation	-,128
	N	13
HLM1	Pearson Correlation	-,110
	N	38
HCM7	Pearson Correlation	,057
	N	43
FHBM18	Pearson Correlation	,118
	N	52
FLM1	Pearson Correlation	-,086
	N	40
FCM8	Pearson Correlation	,304*
	N	45

**. Correlation is significant at the 0,01 level (2-tailed).

*. Correlation is significant at the 0,05 level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.

Medieval - males

		AGEGROUP
C3M2	Pearson Correlation	.134
	N	63
C3M1	Pearson Correlation	.156
	N	62
C3M6	Pearson Correlation	.394**
	N	59
C3M9	Pearson Correlation	.077
	N	57
C3PHL	Pearson Correlation	.265*
	N	60
C3PHR	Pearson Correlation	.287*
	N	62
C3M10	Pearson Correlation	-.068
	N	53
C3M11	Pearson Correlation	-.094
	N	60
C3TPW	Pearson Correlation	.167
	N	35
C3IFLCR	Pearson Correlation	-.045
	N	60
C3IFLCA	Pearson Correlation	.024
	N	60
C3IFRCR	Pearson Correlation	-.096
	N	63
C3IFRCA	Pearson Correlation	.051
	N	62
C7M2	Pearson Correlation	-.087
	N	66
C7M1	Pearson Correlation	-.004
	N	67
C7M6	Pearson Correlation	.574**
	N	66
C7M9	Pearson Correlation	.246*
	N	66
C7PHL	Pearson Correlation	.035
	N	64
C7PHR	Pearson Correlation	.141
	N	63
C7M10	Pearson Correlation	-.035
	N	61
C7M11	Pearson Correlation	.204
	N	66
C7SPL	Pearson Correlation	.088
	N	37
C7IFLCR	Pearson Correlation	-.006
	N	64
C7IFLCA	Pearson Correlation	-.101
	N	61
C7IFRCR	Pearson Correlation	-.212
	N	65
C7IFRCA	Pearson Correlation	-.072
	N	64
T1M2	Pearson Correlation	.091
	N	70
T1M1	Pearson Correlation	.203
	N	70

		AGEGROUP
T1M6	Pearson Correlation	.437**
	N	66
T1M9	Pearson Correlation	.336**
	N	70
T1PHL	Pearson Correlation	.227
	N	66
T1PHR	Pearson Correlation	.251*
	N	67
T1M10	Pearson Correlation	.120
	N	61
T1M11	Pearson Correlation	.163
	N	62
T1SPL	Pearson Correlation	.198
	N	38
T1TPW	Pearson Correlation	.285*
	N	52
T1IFLCR	Pearson Correlation	-.002
	N	65
T1IFLCA	Pearson Correlation	.102
	N	63
T1IFRCR	Pearson Correlation	-.108
	N	61
T1IFRCA	Pearson Correlation	.012
	N	60
T6M2	Pearson Correlation	.345**
	N	64
T6M1	Pearson Correlation	.145
	N	63
T6M6	Pearson Correlation	.362**
	N	60
T6M9	Pearson Correlation	.337**
	N	62
T6PHL	Pearson Correlation	.213
	N	59
T6PHR	Pearson Correlation	.212
	N	61
T6M10	Pearson Correlation	.181
	N	51
T6M11	Pearson Correlation	.283*
	N	60
T6SPL	Pearson Correlation	.046
	N	14
T6TPW	Pearson Correlation	.407*
	N	30
T6IFLCA	Pearson Correlation	-.059
	N	46
T6IFRCA	Pearson Correlation	-.278
	N	46
T10M2	Pearson Correlation	.091
	N	71
T10M1	Pearson Correlation	.077
	N	70
T10M6	Pearson Correlation	.413**
	N	69
T10M9	Pearson Correlation	.412**
	N	70

		AGEGROUP
T10PHL	Pearson Correlation	,273*
	N	67
T10PHR	Pearson Correlation	,341**
	N	67
T10M10	Pearson Correlation	,033
	N	64
T10M11	Pearson Correlation	,136
	N	67
T10SPL	Pearson Correlation	,314
	N	24
T10TPW	Pearson Correlation	,234
	N	40
T10IFLCA	Pearson Correlation	-,210
	N	60
T10IFRCA	Pearson Correlation	-,173
	N	61
L1M2	Pearson Correlation	,060
	N	82
L1M1	Pearson Correlation	,169
	N	77
L1M6	Pearson Correlation	,319**
	N	72
L1M9	Pearson Correlation	,278*
	N	81
L1PHL	Pearson Correlation	,182
	N	77
L1PHR	Pearson Correlation	,114
	N	78
L1M10	Pearson Correlation	-,001
	N	69
L1M11	Pearson Correlation	,215
	N	74
L1SPL	Pearson Correlation	,228
	N	27
L1TPW	Pearson Correlation	,308
	N	27
L1IFLCR	Pearson Correlation	,081
	N	71
L1IFLCA	Pearson Correlation	,052
	N	66
L1IFRCR	Pearson Correlation	-,115
	N	68
L1IFRCA	Pearson Correlation	,121
	N	66
L5M2	Pearson Correlation	,225
	N	73
L5M1	Pearson Correlation	,236*
	N	71
L5M6	Pearson Correlation	,163
	N	69
L5M9	Pearson Correlation	,378**
	N	73
L5PHL	Pearson Correlation	,322**
	N	71
L5PHR	Pearson Correlation	,296*
	N	71

		AGEGROUP
L5M10	Pearson Correlation	,204
	N	59
L5M11	Pearson Correlation	,255*
	N	64
L5SPL	Pearson Correlation	-,170
	N	30
L5TPW	Pearson Correlation	,256
	N	28
L5IFLCR	Pearson Correlation	,021
	N	67
L5IFLCA	Pearson Correlation	,076
	N	59
L5IFRCR	Pearson Correlation	,087
	N	67
L5IFRCA	Pearson Correlation	,188
	N	58
FMM16	Pearson Correlation	-,117
	N	18
FMM7	Pearson Correlation	-,336
	N	17
HLM1	Pearson Correlation	,320**
	N	66
HCM7	Pearson Correlation	,286**
	N	85
FHBM18	Pearson Correlation	,337**
	N	80
FLM1	Pearson Correlation	,263*
	N	68
FCM8	Pearson Correlation	,280*
	N	83

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Medieval - females

		AGEGROUP
C3M2	Pearson Correlation	.061
	N	63
C3M1	Pearson Correlation	.140
	N	64
C3M6	Pearson Correlation	.395**
	N	61
C3M9	Pearson Correlation	.004
	N	61
C3PHL	Pearson Correlation	.174
	N	63
C3PHR	Pearson Correlation	.169
	N	63
C3M10	Pearson Correlation	-.213
	N	50
C3M11	Pearson Correlation	.034
	N	61
C3TPW	Pearson Correlation	-.014
	N	36
C3IFLCR	Pearson Correlation	-.200
	N	61
C3IFLCA	Pearson Correlation	-.244
	N	61
C3IFRCR	Pearson Correlation	-.029
	N	61
C3IFRCA	Pearson Correlation	-.138
	N	61
C7M2	Pearson Correlation	.104
	N	65
C7M1	Pearson Correlation	.049
	N	66
C7M6	Pearson Correlation	.437**
	N	65
C7M9	Pearson Correlation	.311*
	N	64
C7PHL	Pearson Correlation	.114
	N	64
C7PHR	Pearson Correlation	.011
	N	68
C7M10	Pearson Correlation	.025
	N	60
C7M11	Pearson Correlation	-.011
	N	63
C7SPL	Pearson Correlation	-.125
	N	35
C7IFLCR	Pearson Correlation	-.313*
	N	58
C7IFLCA	Pearson Correlation	-.096
	N	57
C7IFRCR	Pearson Correlation	-.254
	N	59
C7IFRCA	Pearson Correlation	-.256
	N	58
T1M2	Pearson Correlation	.170
	N	69
T1M1	Pearson Correlation	-.040
	N	68

		AGEGROUP
T1M6	Pearson Correlation	.369**
	N	64
T1M9	Pearson Correlation	.247*
	N	66
T1PHL	Pearson Correlation	.196
	N	63
T1PHR	Pearson Correlation	.158
	N	69
T1M10	Pearson Correlation	.069
	N	56
T1M11	Pearson Correlation	.138
	N	65
T1SPL	Pearson Correlation	-.374
	N	25
T1TPW	Pearson Correlation	-.100
	N	47
T1IFLCR	Pearson Correlation	-.115
	N	61
T1IFLCA	Pearson Correlation	-.067
	N	59
T1IFRCR	Pearson Correlation	-.202
	N	65
T1IFRCA	Pearson Correlation	-.058
	N	60
T6M2	Pearson Correlation	-.007
	N	67
T6M1	Pearson Correlation	-.034
	N	66
T6M6	Pearson Correlation	.339**
	N	65
T6M9	Pearson Correlation	.141
	N	67
T6PHL	Pearson Correlation	.170
	N	62
T6PHR	Pearson Correlation	.101
	N	63
T6M10	Pearson Correlation	-.075
	N	54
T6M11	Pearson Correlation	.203
	N	62
T6SPL	Pearson Correlation	-.143
	N	18
T6TPW	Pearson Correlation	.235
	N	41
T6IFLCA	Pearson Correlation	.102
	N	50
T6IFRCA	Pearson Correlation	.035
	N	47
T10M2	Pearson Correlation	.066
	N	67
T10M1	Pearson Correlation	-.067
	N	66
T10M6	Pearson Correlation	.019
	N	67
T10M9	Pearson Correlation	.242*
	N	63

		AGEGROUP
T10PHL	Pearson Correlation	.185
	N	65
T10PHR	Pearson Correlation	.057
	N	65
T10M10	Pearson Correlation	.027
	N	58
T10M11	Pearson Correlation	.047
	N	63
T10SPL	Pearson Correlation	.062
	N	22
T10TPW	Pearson Correlation	-.002
	N	41
T10IFLCA	Pearson Correlation	.298*
	N	55
T10IFRCA	Pearson Correlation	.122
	N	55
L1M2	Pearson Correlation	-.164
	N	71
L1M1	Pearson Correlation	-.068
	N	70
L1M6	Pearson Correlation	-.044
	N	66
L1M9	Pearson Correlation	.144
	N	69
L1PHL	Pearson Correlation	.047
	N	66
L1PHR	Pearson Correlation	.046
	N	71
L1M10	Pearson Correlation	-.036
	N	58
L1M11	Pearson Correlation	.199
	N	69
L1SPL	Pearson Correlation	.334
	N	22
L1TPW	Pearson Correlation	-.571**
	N	23
L1IFLCR	Pearson Correlation	.174
	N	58
L1IFLCA	Pearson Correlation	.024
	N	53
L1IFRCR	Pearson Correlation	.170
	N	57
L1IFRCA	Pearson Correlation	.056
	N	56
L5M2	Pearson Correlation	.076
	N	68
L5M1	Pearson Correlation	.045
	N	62
L5M6	Pearson Correlation	.093
	N	62
L5M9	Pearson Correlation	.380**
	N	67
L5PHL	Pearson Correlation	.052
	N	63
L5PHR	Pearson Correlation	-.030
	N	64

		AGEGROUP
L5M10	Pearson Correlation	-.057
	N	57
L5M11	Pearson Correlation	.170
	N	61
L5SPL	Pearson Correlation	.224
	N	24
L5TPW	Pearson Correlation	-.058
	N	31
L5IFLCR	Pearson Correlation	-.138
	N	64
L5IFLCA	Pearson Correlation	-.006
	N	59
L5IFRCR	Pearson Correlation	-.125
	N	61
L5IFRCA	Pearson Correlation	-.201
	N	58
FMM16	Pearson Correlation	-.293
	N	17
FMM7	Pearson Correlation	-.010
	N	17
HLM1	Pearson Correlation	-.110
	N	54
HCM7	Pearson Correlation	.032
	N	75
FHBM18	Pearson Correlation	.063
	N	74
FLM1	Pearson Correlation	-.246*
	N	64
FCM8	Pearson Correlation	.065
	N	77

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level (2-tailed).

Modern - males

		AGEGROUP
C3M2	Pearson Correlation	,293
	N	38
C3M1	Pearson Correlation	,183
	N	38
C3M6	Pearson Correlation	,601**
	N	36
C3M9	Pearson Correlation	,580**
	N	37
C3PHL	Pearson Correlation	,468**
	N	35
C3PHR	Pearson Correlation	,456**
	N	33
C3M10	Pearson Correlation	-,101
	N	34
C3M11	Pearson Correlation	,310
	N	38
C3TPW	Pearson Correlation	,297
	N	22
C3IFLCR	Pearson Correlation	-,269
	N	37
C3IFLCA	Pearson Correlation	-,065
	N	35
C3IFRCR	Pearson Correlation	-,124
	N	34
C3IFRCA	Pearson Correlation	,032
	N	35
C7M2	Pearson Correlation	,125
	N	38
C7M1	Pearson Correlation	,119
	N	37
C7M6	Pearson Correlation	,587**
	N	36
C7M9	Pearson Correlation	,470**
	N	36
C7PHL	Pearson Correlation	,043
	N	36
C7PHR	Pearson Correlation	,192
	N	38
C7M10	Pearson Correlation	,019
	N	38
C7M11	Pearson Correlation	,003
	N	38
C7SPL	Pearson Correlation	-,013
	N	23
C7IFLCR	Pearson Correlation	-,200
	N	35
C7IFLCA	Pearson Correlation	,147
	N	38
C7IFRCR	Pearson Correlation	-,243
	N	35
C7IFRCA	Pearson Correlation	,167
	N	37
T1M2	Pearson Correlation	,166
	N	40
T1M1	Pearson Correlation	,085
	N	38

		AGEGROUP
T1M6	Pearson Correlation	,640**
	N	34
T1M9	Pearson Correlation	,438**
	N	38
T1PHL	Pearson Correlation	,352*
	N	40
T1PHR	Pearson Correlation	,404*
	N	39
T1M10	Pearson Correlation	,206
	N	38
T1M11	Pearson Correlation	,271
	N	40
T1SPL	Pearson Correlation	-,036
	N	20
T1TPW	Pearson Correlation	,471**
	N	35
T1IFLCR	Pearson Correlation	-,113
	N	38
T1IFLCA	Pearson Correlation	,090
	N	39
T1IFRCR	Pearson Correlation	-,045
	N	35
T1IFRCA	Pearson Correlation	,178
	N	39
T6M2	Pearson Correlation	,225
	N	36
T6M1	Pearson Correlation	,073
	N	35
T6M6	Pearson Correlation	,386*
	N	34
T6M9	Pearson Correlation	,126
	N	36
T6PHL	Pearson Correlation	,398*
	N	35
T6PHR	Pearson Correlation	,417*
	N	36
T6M10	Pearson Correlation	,200
	N	34
T6M11	Pearson Correlation	-,059
	N	36
T6SPL	Pearson Correlation	-,411
	N	13
T6TPW	Pearson Correlation	,126
	N	27
T6IFLCA	Pearson Correlation	,224
	N	32
T6IFRCA	Pearson Correlation	,137
	N	32
T10M2	Pearson Correlation	,200
	N	38
T10M1	Pearson Correlation	-,006
	N	34
T10M6	Pearson Correlation	,220
	N	31
T10M9	Pearson Correlation	,515**
	N	39

		AGEGROUP
T10PHL	Pearson Correlation	,105
	N	40
T10PHR	Pearson Correlation	,182
	N	38
T10M10	Pearson Correlation	,229
	N	38
T10M11	Pearson Correlation	,016
	N	40
T10SPL	Pearson Correlation	,236
	N	11
T10TPW	Pearson Correlation	,118
	N	24
T10IFLCA	Pearson Correlation	-,006
	N	38
T10IFRCA	Pearson Correlation	-,086
	N	37
L1M2	Pearson Correlation	.063
	N	36
L1M1	Pearson Correlation	.329
	N	36
L1M6	Pearson Correlation	,091
	N	33
L1M9	Pearson Correlation	.359*
	N	37
L1PHL	Pearson Correlation	.295
	N	35
L1PHR	Pearson Correlation	.396*
	N	36
L1M10	Pearson Correlation	,143
	N	34
L1M11	Pearson Correlation	,042
	N	35
L1SPL	Pearson Correlation	,535
	N	8
L1TPW	Pearson Correlation	.029
	N	16
L1IFLCR	Pearson Correlation	-,028
	N	34
L1IFLCA	Pearson Correlation	,111
	N	34
L1IFRCR	Pearson Correlation	,164
	N	32
L1IFRCA	Pearson Correlation	,285
	N	34
L5M2	Pearson Correlation	,141
	N	36
L5M1	Pearson Correlation	.095
	N	37
L5M6	Pearson Correlation	.433*
	N	32
L5M9	Pearson Correlation	.568**
	N	38
L5PHL	Pearson Correlation	,225
	N	38
L5PHR	Pearson Correlation	,286
	N	37

		AGEGROUP
L5M10	Pearson Correlation	-,076
	N	35
L5M11	Pearson Correlation	,120
	N	38
L5SPL	Pearson Correlation	,572
	N	11
L5TPW	Pearson Correlation	,193
	N	18
L5IFLCR	Pearson Correlation	,437**
	N	38
L5IFLCA	Pearson Correlation	,068
	N	37
L5IFRCR	Pearson Correlation	,261
	N	35
L5IFRCA	Pearson Correlation	-,068
	N	36
FMM16	Pearson Correlation	,252
	N	28
FMM7	Pearson Correlation	-,062
	N	28
HLM1	Pearson Correlation	.205
	N	36
HCM7	Pearson Correlation	.433**
	N	40
FHBM18	Pearson Correlation	,207
	N	39
FLM1	Pearson Correlation	-,119
	N	36
FCM8	Pearson Correlation	.275
	N	39

**. Correlation is significant at the 0,01 level

*. Correlation is significant at the 0,05 level (2-tailed).

Modern - females

		AGEGROUP
C3M2	Pearson Correlation	-.062
	N	26
C3M1	Pearson Correlation	-.308
	N	24
C3M6	Pearson Correlation	.344
	N	25
C3M9	Pearson Correlation	.369
	N	25
C3PHL	Pearson Correlation	.205
	N	27
C3PHR	Pearson Correlation	.161
	N	26
C3M10	Pearson Correlation	.107
	N	24
C3M11	Pearson Correlation	-.184
	N	26
C3TPW	Pearson Correlation	-.493*
	N	17
C3IFLCR	Pearson Correlation	.071
	N	26
C3IFLCA	Pearson Correlation	.008
	N	27
C3IFRCR	Pearson Correlation	-.012
	N	26
C3IFRCA	Pearson Correlation	-.002
	N	26
C7M2	Pearson Correlation	-.047
	N	26
C7M1	Pearson Correlation	-.179
	N	25
C7M6	Pearson Correlation	.173
	N	26
C7M9	Pearson Correlation	.256
	N	26
C7PHL	Pearson Correlation	.167
	N	26
C7PHR	Pearson Correlation	.399*
	N	27
C7M10	Pearson Correlation	.324
	N	26
C7M11	Pearson Correlation	-.048
	N	27
C7SPL	Pearson Correlation	-.456
	N	14
C7IFLCR	Pearson Correlation	-.270
	N	26
C7IFLCA	Pearson Correlation	.269
	N	28
C7IFRCR	Pearson Correlation	.056
	N	25
C7IFRCA	Pearson Correlation	.183
	N	24
T1M2	Pearson Correlation	-.096
	N	28
T1M1	Pearson Correlation	-.239
	N	27

		AGEGROUP
T1M6	Pearson Correlation	.002
	N	27
T1M9	Pearson Correlation	.215
	N	28
T1PHL	Pearson Correlation	.130
	N	28
T1PHR	Pearson Correlation	.224
	N	28
T1M10	Pearson Correlation	.316
	N	28
T1M11	Pearson Correlation	.208
	N	28
T1SPL	Pearson Correlation	-.377
	N	13
T1TPW	Pearson Correlation	.127
	N	25
T1IFLCR	Pearson Correlation	.047
	N	28
T1IFLCA	Pearson Correlation	.141
	N	27
T1IFRCR	Pearson Correlation	-.007
	N	28
T1IFRCA	Pearson Correlation	.258
	N	27
T6M2	Pearson Correlation	.068
	N	26
T6M1	Pearson Correlation	.005
	N	27
T6M6	Pearson Correlation	.212
	N	27
T6M9	Pearson Correlation	-.199
	N	28
T6PHL	Pearson Correlation	-.193
	N	27
T6PHR	Pearson Correlation	.058
	N	27
T6M10	Pearson Correlation	.348
	N	26
T6M11	Pearson Correlation	.183
	N	27
T6SPL	Pearson Correlation	.369
	N	11
T6TPW	Pearson Correlation	.297
	N	22
T6IFLCA	Pearson Correlation	.181
	N	24
T6IFRCA	Pearson Correlation	.182
	N	25
T10M2	Pearson Correlation	-.141
	N	28
T10M1	Pearson Correlation	-.164
	N	28
T10M6	Pearson Correlation	-.021
	N	26
T10M9	Pearson Correlation	-.038
	N	28

		AGEGROUP
T10PHL	Pearson Correlation	.273
	N	28
T10PHR	Pearson Correlation	.166
	N	27
T10M10	Pearson Correlation	.233
	N	27
T10M11	Pearson Correlation	.027
	N	28
T10SPL	Pearson Correlation	-.099
	N	13
T10TPW	Pearson Correlation	.214
	N	22
T10IFLCA	Pearson Correlation	.049
	N	28
T10IFRCA	Pearson Correlation	.189
	N	27
L1M2	Pearson Correlation	-.006
	N	27
L1M1	Pearson Correlation	-.269
	N	25
L1M6	Pearson Correlation	.255
	N	25
L1M9	Pearson Correlation	-.075
	N	28
L1PHL	Pearson Correlation	.320
	N	27
L1PHR	Pearson Correlation	.313
	N	28
L1M10	Pearson Correlation	.023
	N	28
L1M11	Pearson Correlation	.296
	N	28
L1SPL	Pearson Correlation	-.132
	N	13
L1TPW	Pearson Correlation	.003
	N	15
L1IFLCR	Pearson Correlation	.119
	N	28
L1IFLCA	Pearson Correlation	-.065
	N	27
L1IFRCR	Pearson Correlation	.192
	N	27
L1IFRCA	Pearson Correlation	.087
	N	27
L5M2	Pearson Correlation	-.144
	N	26
L5M1	Pearson Correlation	-.394
	N	24
L5M6	Pearson Correlation	.106
	N	23
L5M9	Pearson Correlation	.406*
	N	27
L5PHL	Pearson Correlation	.241
	N	26
L5PHR	Pearson Correlation	.208
	N	28

		AGEGROUP
L5M10	Pearson Correlation	.115
	N	25
L5M11	Pearson Correlation	.191
	N	27
L5SPL	Pearson Correlation	-.199
	N	13
L5TPW	Pearson Correlation	-.148
	N	15
L5IFLCR	Pearson Correlation	.150
	N	27
L5IFLCA	Pearson Correlation	.189
	N	27
L5IFRCR	Pearson Correlation	.041
	N	27
L5IFRCA	Pearson Correlation	.086
	N	27
FMM16	Pearson Correlation	.197
	N	21
FMM7	Pearson Correlation	.122
	N	21
HLM1	Pearson Correlation	-.315
	N	29
HCM7	Pearson Correlation	-.280
	N	30
FHBM18	Pearson Correlation	-.133
	N	29

*. Correlation is significant at the 0.05 level (2-tailed).

9. Inter-correlations of variables (Female values below diagonal line and in italic)

	C3M2	C3M1	C3M6	C3M9	C3PHL	C3PHR	C3M10	C3M11	C3TPW	C3IFLCR	C3IFLCA	C3IFRCR	C3IFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
C3M2	1	.642**	.267**	.223*	.579**	.520**	.018	.442**	.333**	.046	.134	.194*	.117
C3M1	.688**	1	.180*	.089	.420**	.376**	.220*	.304**	.287*	.027	.076	.208*	.105
C3M6	.234**	.217*	1	.311**	.406**	.428**	-.308**	.096	.189	-.233*	-.126	-.271**	-.239**
C3M9	.214*	.031	.172	1	.329**	.255**	-.062	.146	.210	-.026	-.081	.025	.056
C3PHL	.519**	.321**	.352**	.276**	1	.723**	-.166	.127	.285*	-.177	-.086	-.091	-.024
C3PHR	.476**	.236**	.368**	.213*	.666**	1	-.168	.088	.286*	-.041	.087	-.033	-.020
C3M10	.090	-.073	-.224*	.020	-.088	-.020	1	.336**	.263*	.403**	.334**	.359**	.380**
C3M11	.304**	.066	-.092	.219*	-.049	.069	.256**	1	.540**	.426**	.486**	.308**	.370**
C3TPW	.298*	.084	.197	.253*	.250*	.367**	.070	.535**	1	.287*	.384**	.300*	.272*
C3IFLCR	.200*	.000	-.258**	-.071	-.220*	-.130	.266**	.533**	.204	1	.559**	.581**	.538**
C3IFLCA	.266**	.043	-.372**	-.142	-.028	.001	.366**	.443**	.161	.626**	1	.555**	.727**
C3IFRCR	.199*	.018	-.220*	-.024	-.133	-.218*	.245*	.522**	.166	.705**	.510**	1	.520**
C3IFRCA	.192*	.012	-.344**	-.047	-.098	-.111	.420**	.497**	.206	.643**	.769**	.675**	1
C7M2	.659**	.496**	.141	.188	.383**	.399**	.213	.367**	.358**	.230*	.360**	.258**	.300**
C7M1	.606**	.480**	.188	.199*	.484**	.469**	.221*	.261**	.267*	.095	.180	.143	.157
C7M6	.248*	.174	.541**	.239*	.256**	.359**	.060	.209*	.407**	.040	.033	-.102	-.086
C7M9	.107	.028	.282**	.382**	.255**	.216*	-.043	.137	.229	-.104	.050	-.095	-.043
C7PHL	.314**	.221*	.253*	.143	.411**	.465**	.056	.112	.225	.092	.074	-.085	.077
C7PHR	.293**	.198*	.286**	.284**	.377**	.522**	.037	.141	.410**	.085	.111	-.145	.063
C7M10	.163	-.029	-.063	.069	-.025	.118	.590**	.472**	-.025	.315**	.279**	.385**	.446**
C7M11	.168	.051	-.009	.061	-.119	.031	.358**	.651**	.178	.287**	.207*	.170	.262**
C7SPL	-.048	.046	-.183	.117	-.174	-.207	.096	-.068	-.005	-.066	.074	-.012	.048
C7IFLCR	.118	.032	-.231*	.068	-.122	-.105	.327**	.454**	.315*	.471**	.471**	.516**	.489**
C7IFLCA	.149	.005	-.131	.008	-.171	-.016	.498**	.486**	.046	.483**	.451**	.481**	.534**
C7IFRCR	.218*	.045	-.244*	.034	-.106	-.049	.452**	.525**	.286*	.519**	.537**	.538**	.559**
C7IFRCA	.175	.039	-.115	-.047	-.073	-.011	.491**	.417**	-.047	.474**	.548**	.470**	.547**
T1M2	.644**	.445**	.256**	.236*	.423**	.374**	.293**	.340**	.349**	.196*	.233*	.182	.196*
T1M1	.471**	.396**	.095	.174	.339**	.384**	.224*	.136	.366**	.053	.123	-.056	.043
T1M6	.299**	.210*	.529**	.227*	.296**	.357**	.145	.072	.254*	-.083	-.012	-.075	-.046
T1M9	.256**	.108	.284**	.302**	.216*	.233*	-.136	.194	.326**	.024	.042	.058	.117
T1PHL	.394**	.302**	.301**	.156	.396**	.568**	.151	.105	.319*	.043	.056	-.038	.072
T1PHR	.299**	.175	.204*	.131	.364**	.473**	.186	.054	.233	-.011	-.018	-.034	.073
T1M10	.086	-.076	-.044	.092	-.068	.113	.600**	.499**	.139	.371**	.305**	.382**	.414**
T1M11	.223*	.041	.093	.015	.010	.109	.259*	.564**	.203	.253*	.150	.128	.204*
T1SPL	.135	.022	.053	.467**	.155	.101	-.019	.164	.546**	-.057	.113	.189	-.097
T1TPW	.111**	.125	.306**	.187	.342**	.381**	.016	.168	.250	.000	-.032	.041	-.072

	C3M2	C3M1	C3M6	C3M9	C3PHL	C3PHR	C3M10	C3M11	C3TPW	C3IFLCR	C3IFLCA	C3IFRCR	C3IFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
T1IFLCR	.197	.090	-.151	.174	-.042	-.087	.390**	.324**	.042	.392**	.386**	.479**	.342**
T1IFLCA	.088	-.166	-.180	-.030	-.198	-.160	.497**	.377**	.033	.396**	.507**	.485**	.525**
T1IFRCR	.146	.006	-.073	.130	-.086	-.070	.554**	.380**	.165	.353**	.328**	.473**	.423**
T1IFRCA	.128	-.107	-.039	.060	-.115	-.019	.456**	.376**	.013	.348**	.354**	.439**	.494**
T6M2	.597**	.403**	.222*	.147	.289**	.386**	.231*	.197	.357**	.122	.125	-.070	.123
T6M1	.446**	.315**	.097	.172	.235*	.294**	.124	.181	.336**	-.061	.019	-.150	.041
T6M6	.370**	.195	.323**	.159	.218*	.348**	.243*	.092	.118	.046	.058	-.063	-.005
T6M9	.328**	.187	.246*	.234*	.290**	.287**	-.014	.229*	.330**	.029	.103	.030	.135
T6PHL	.378**	.148	.252*	.214*	.386**	.473**	.127	.226*	.372**	.127	.019	.104	-.003
T6PHR	.291**	.178	.215*	.283**	.300**	.409**	.178	.227*	.280*	.106	.123	.074	.038
T6M10	-.107	-.266*	-.041	.230*	-.108	-.069	.293*	.375**	-.048	.146	.137	.191	.197
T6M11	.152	-.086	-.061	.191	.067	.072	.229*	.518**	.005	.181	.186	.163	.118
T6SPL	.168	.067	.013	-.227	.318	.006	-.116	-.205	.191	-.091	.186	.129	.155
T6TPW	.078	-.041	.221	.159	.298*	.257*	.189	.087	.268	-.008	-.029	-.005	-.085
T6IFLCA	.230*	.037	.056	.132	-.110	-.068	.070	.290*	.289	.359**	.229*	.291*	.308**
T6IFRCA	.143	.001	-.063	.084	-.113	-.102	.249	.252*	.048	.390**	.361**	.324**	.365**
T10M2	.537**	.473**	.004	.079	.189	.279**	.212*	.247*	.097	-.001	.222*	.027	.156
T10M1	.381**	.277**	.078	.064	.162	.193	.149	.176	.194	.062	.117	.001	-.012
T10M6	.374**	.317**	.211*	.176	.186	.249*	.102	.243*	.127	.078	.100	.094	.067
T10M9	.386**	.318**	.275**	.150	.265**	.295**	-.022	.308**	.353**	.051	.156	.167	.230*
T10PHL	.361**	.298**	.094	.124	.353**	.420**	.228*	.277**	.193	.031	.196	.005	.098
T10PHR	.378**	.305**	.062	.215*	.319**	.401**	.259*	.272**	.210	.052	.187	.078	.097
T10M10	-.064	-.113	-.038	.011	-.148	.141	.365**	.500**	.243	.200	.210*	.188	.235*
T10M11	.256**	.073	-.019	.139	-.149	.073	.345**	.646**	.344**	.441**	.274**	.387**	.319**
T10SPL	.409**	.091	.120	-.116	.382**	.413**	.102	.326*	.401*	.173	.209	.221	.183
T10TPW	.150	.022	.031	-.030	.233	.211	.223	.176	.261	.093	.079	.063	.048
T10IFLCA	.090	-.067	-.285**	-.121	-.286**	-.240*	.221	.420**	-.033	.505**	.463**	.490**	.519**
T10IFRCA	.053	-.138	-.163	-.039	-.204	-.019	.286*	.476**	-.026	.358**	.505**	.342**	.419**
L1M2	.500**	.393**	.127	.158	.320**	.240*	.266*	.098	-.012	.041	.097	.033	.029
L1M1	.440**	.379**	.100	.121	.238*	.166	.258*	.095	.164	.100	.028	-.020	-.012
L1M6	.244*	.176	.292**	.313**	.225*	.210*	.222*	.127	.369**	.013	.068	-.034	.030
L1M9	.332**	.236*	.313**	.269**	.244*	.283**	-.006	.253*	.502**	.021	.051	-.053	.067
L1PHL	.382**	.278**	.188	.226*	.456**	.365**	.229*	.084	.162	.043	.110	.000	-.020
L1PHR	.440**	.352**	.281**	.131	.485**	.398**	.110	.012	.067	.073	.122	.048	.019
L1M10	.108	-.027	-.028	.194	-.080	.075	.374**	.584**	.380**	.304**	.194	.210*	.152
L1M11	.058	-.221*	.107	.045	-.207*	.045	.306**	.418**	.219	.167	.078	.100	.111

	C3M2	C3M1	C3M6	C3M9	C3PHL	C3PHR	C3M10	C3M11	C3TPW	C3IFLCR	C3IFLCA	C3IFRCR	C3IFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
L1SPL	.437**	.310*	.251	.237	.197	.320*	.151	.350*	.247	.032	.156	.068	.084
L1TPW	.315*	.107	.243	.076	.262	.335*	.215	.272	.335	.045	.161	.083	.085
L1IFLCR	.127	.066	-.071	.060	-.260*	-.143	.261*	.400**	.180	.345**	.331**	.351**	.331**
L1IFLCA	.048	-.133	-.249*	.093	-.256*	-.136	.441**	.552**	.207	.506**	.435**	.505**	.414**
L1IFRCR	.237*	.106	-.036	.061	-.034	-.038	.231	.274*	.141	.235*	.254*	.364**	.229*
L1IFRCA	.123	-.046	-.191	.197	-.148	-.002	.453**	.522**	.175	.376**	.336**	.412**	.390**
L5M2	.418**	.418**	.070	.121	.329**	.268**	.196	.104	.280*	.041	.084	.104	.155
L5M1	.222*	.282**	-.052	.089	.128	.119	.108	.210*	.350**	-.059	.068	-.037	.057
L5M6	.297**	.197	.286**	.247*	.251*	.290**	.203	.124	.196	.101	.092	.041	.094
L5M9	.264**	.100	.320**	.466**	.254**	.321**	.155	.227*	.264*	.088	-.031	.130	.110
L5PHL	.201*	.173	.176	.279**	.406**	.336**	.183	.127	.178	.008	.050	.078	.093
L5PHR	.206*	.181	.197*	.221*	.390**	.311**	.118	.164	.172	-.022	.054	.065	.054
L5M10	.000	-.053	.037	.085	-.013	.103	.154	.231*	.096	-.041	-.004	.043	.091
L5M11	.066	-.037	.220*	.039	.075	.135	.281*	.451**	.243	.244*	.334**	.207*	.271**
L5SPL	.168	.146	-.073	.065	-.014	.139	.270	.304*	.624**	.162	.208	-.019	.140
L5TPW	.155	.141	.063	-.137	.016	.067	.154	.001	.112	.035	.133	.054	.097
L5IFLCR	.214*	.046	.033	.138	.015	-.008	.408**	.279**	-.078	.148	.279**	.251*	.240*
L5IFLCA	-.024	-.005	-.027	-.125	-.125	-.155	.183	.195	.030	.170	.072	.246*	.134
L5IFRCR	.117	.000	-.043	.109	-.026	-.037	.368**	.367**	.096	.212*	.294**	.305**	.289**
L5IFRCA	.014	-.110	-.012	.013	.010	-.085	.224*	.236*	.075	.146	.116	.175	.117
FMM16	-.062	-.252	.053	.228	-.024	-.074	.300	.350*	-.077	.333*	.251	.295	-.020
FMM7	-.081	-.111	-.085	-.055	-.040	-.060	.228	.482**	.207	.385*	.220	.169	.115
HLM1	.414**	.247*	.012	.132	.131	.197	.243*	.448**	.260	.264*	.308**	.287**	.294**
HCM7	.415**	.268**	.224*	.156	.426**	.429**	.022	.070	.329**	-.106	-.009	-.155	.049
FHBM18	.426**	.208*	.096	.172	.219*	.288**	.389**	.455**	.435**	.233*	.299**	.216*	.272**
FLM1	.354**	.174	-.085	.028	.027	.085	.164	.387**	.264	.288**	.285**	.208*	.221*
FCM8	.340**	.177	.269**	.083	.278**	.310**	.088	.310**	.289*	-.069	.012	-.098	-.006
RIWM2	.221	.134	.158	.170	.124	.179	.038	.438**	.189	.306*	.245	.315*	.012

	C7M2	C7M1	C7M6	C7M9	C7PHL	C7PHR	C7M10	C7M11	C7SPL	C7IFLCR	C7IFLCA	C7IFRCR	C7IFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
C3M2	.598**	.475**	.367**	.281**	.496**	.418**	.149	.134	.391**	-.086	.075	-.044	.172
C3M1	.502**	.373**	.294**	.215*	.467**	.442**	.067	.148	.255*	-.017	.035	.007	.093
C3M6	.120	.076	.596**	.345**	.187	.206*	-.072	.084	.310*	-.275**	-.119	-.256**	-.048
C3M9	.138	.095	.179	.382**	.043	.067	.127	-.041	.098	-.027	.103	-.033	.113
C3PHL	.375**	.330**	.201*	.290**	.454**	.462**	-.047	-.025	.544**	-.155	.011	-.128	.005
C3PHR	.429**	.444**	.277**	.143	.446**	.486**	-.070	-.073	.247	-.134	-.010	-.113	.091
C3M10	.102	-.019	-.028	-.005	.021	.129	.561**	.338**	.103	.364**	.386**	.461**	.365**
C3M11	.384**	.292**	.193*	.205*	.128	.079	.443**	.381**	.233	.197*	.401**	.293**	.438**
C3TPW	.350**	.291*	.301*	.096	.125	.218	.248*	.205	.303	.150	.238	.094	.360**
C3IFLCR	.104	.076	-.105	-.087	.068	.116	.356**	.242*	-.013	.382**	.355**	.424**	.432**
C3IFLCA	.212*	.115	-.051	.074	.133	.141	.302**	.082	.121	.381**	.488**	.366**	.531**
C3IFRCR	.122	.048	-.182	-.044	.078	.057	.327**	.183	-.032	.368**	.384**	.393**	.405**
C3IFRCA	.156	.059	-.111	.033	.139	.126	.316**	.111	.193	.423**	.432**	.433**	.428**
C7M2	1	.769**	.009	.058	.490**	.511**	.318**	.027	.395**	.088	.294**	.113	.334**
C7M1	.797**	1	-.110	-.032	.283**	.328**	.227*	-.133	.308**	.072	.220*	.057	.274**
C7M6	.202*	.127	1	.415**	.176	.173	-.134	.200*	.052	-.172	-.133	-.237**	-.038
C7M9	.114	.080	.266**	1	.117	.075	-.083	.067	.217	-.162	-.023	-.176	-.042
C7PHL	.450**	.415**	.307**	.196*	1	.742**	.028	-.052	.264*	-.146	.001	-.038	.054
C7PHR	.374**	.342**	.307**	.173	.787**	1	.080	-.116	.224	-.013	.149	-.017	.143
C7M10	.244**	.201*	-.145	-.083	.038	.025	1	.261**	.089	.376**	.539**	.434**	.564**
C7M11	.085	-.049	.108	-.042	-.037	-.001	.534**	1	-.117	.194*	.118	.278**	.203*
C7SPL	.067	.173	-.138	.153	-.231	-.330**	.007	-.173	1	-.079	.066	-.077	.109
C7IFLCR	.253**	.252**	.020	-.095	-.082	-.049	.380**	.257**	.205	1	.513**	.701**	.479**
C7IFLCA	.225*	.133	.075	.039	.055	.052	.593**	.377**	.049	.565**	1	.379**	.767**
C7IFRCR	.250**	.172	.064	-.056	.025	.000	.450**	.382**	.156	.740**	.637**	1	.384**
C7IFRCA	.272**	.160	.035	.000	.018	.012	.519**	.339**	.104	.563**	.800**	.589**	1
T1M2	.773**	.653**	.203*	.069	.345**	.309**	.230*	.204*	-.073	.098	.037	.113	.134
T1M1	.631**	.691**	.179	-.018	.396**	.340**	.099	.046	.125	.073	.013	.030	.099
T1M6	.284**	.211*	.785**	.196*	.256**	.246**	-.072	.089	-.104	.109	.096	.062	.137
T1M9	.225*	.159	.194*	.440**	.159	.233*	.123	.159	-.131	.072	.145	.053	.077
T1PHL	.474**	.587**	.291**	.106	.549**	.643**	.037	-.057	-.070	-.006	.060	-.077	.023
T1PHR	.495**	.552**	.201*	.042	.571**	.602**	.056	-.053	-.071	.002	.068	-.110	.036
T1M10	.162	.080	.011	.015	.002	.111	.841**	.585**	-.094	.370**	.652**	.491**	.509**
T1M11	.096	-.076	.143	.043	-.005	.038	.536**	.771**	-.255*	.093	.317**	.362**	.320**
T1SPL	.025	.070	.123	.094	-.085	-.060	-.140	.036	.282	.092	-.231	.188	-.163
T1TPW	.224*	.120	.146**	.122	.030	.151	.071	.207	-.017	-.004	.015	.077	.086

	C7M2	C7M1	C7M6	C7M9	C7PHL	C7PHR	C7M10	C7M11	C7SPL	C7IFLCR	C7IFLCA	C7IFRCR	C7IFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
T1IFLCR	.067	.006	-.025	-.036	-.174	-.139	.454**	.216*	.113	.626**	.605**	.558**	.642**
T1IFLCA	.190	.036	-.002	-.083	-.096	-.016	.523**	.266**	.177	.536**	.696**	.577**	.674**
T1IFRCR	.123	.091	.107	.010	-.027	-.012	.510**	.356**	.113	.520**	.574**	.624**	.667**
T1IFRCA	.229*	.098	-.003	-.145	-.014	.079	.644**	.340**	.044	.398**	.657**	.481**	.706**
T6M2	.579**	.487**	.263**	-.038	.212*	.215*	.126	.152	.094	.070	.055	.135	.108
T6M1	.450**	.371**	.207*	.073	.174	.156	.038	.109	.155	-.058	-.071	.141	-.077
T6M6	.291**	.133	.539**	.034	.195	.307**	.093	.077	.024	.058	.190	.064	.150
T6M9	.258**	.190	.369**	.317**	.330**	.354**	-.126	.112	-.317*	.019	-.087	-.073	-.163
T6PHL	.304**	.352**	.189	.015	.306**	.192	.150	.170	-.032	.031	.020	.081	-.025
T6PHR	.242*	.333**	.235*	.065	.291**	.292**	.195	.185	.025	.052	.124	.104	.216*
T6M10	-.003	-.128	.164	.095	.053	.029	.558**	.410**	-.076	.289**	.482**	.421**	.414**
T6M11	.161	.151	.142	.159	.169	.182	.410**	.475**	-.101	.295**	.387**	.324**	.232*
T6SPL	.241	.192	.245	-.178	.208	.261	-.140	-.099	.063	-.164	-.274	.021	-.372*
T6TPW	.148	.072	.166	.212	.147	.252*	.084	.055	-.072	-.082	.028	.019	-.024
T6IFLCA	.228*	.185	.200	.170	.096	.146	.119	.092	.003	.245*	.193	.241*	.107
T6IFRCA	.196	.190	.119	.180	.097	.156	.178	.099	-.017	.213	.097	.233*	.149
T10M2	.522**	.434**	.191*	.007	.135	-.025	.213*	.309**	.115	.136	.151	.232*	.077
T10M1	.338**	.287**	.114	-.025	.178	.079	.086	.133	.103	-.017	-.129	.053	-.085
T10M6	.330**	.247*	.447**	.010	.147	.167	.067	.225*	.074	.110	.132	.064	.170
T10M9	.327**	.241*	.398**	.229*	.269**	.285**	.035	.190	-.124	.148	.153	.077	-.049
T10PHL	.372**	.356**	.236*	.020	.326**	.258**	.269**	.304**	-.037	.111	.145	.173	.080
T10PHR	.386**	.402**	.289**	.073	.316**	.241*	.204*	.147	.127	.184	.147	.130	.131
T10M10	.108	-.024	.128	-.059	-.171	-.064	.646**	.620**	.192	.351**	.438**	.412**	.387**
T10M11	.322**	.132	.304**	.105	.084	.097	.421**	.505**	.176	.402**	.464**	.473**	.351**
T10SPL	.265	.324*	.380*	.098	.185	.158	-.026	.143	-.369*	-.023	-.055	.162	-.078
T10TPW	.052	.040	.121	-.062	-.004	.115	.091	.161	.215	.032	.055	.163	.036
T10IFLCA	.175	-.026	.069	-.125	-.169	-.117	.352**	.286**	-.036	.292**	.504**	.364**	.436**
T10IFRCA	.168	-.005	.146	.036	-.170	-.132	.389**	.328**	.081	.262*	.502**	.378**	.557**
L1M2	.474**	.500**	.151	.048	.191	-.001	-.077	.024	.127	.062	-.081	.093	-.017
L1M1	.458**	.521**	.192	.033	.295**	.174	-.110	.020	.101	.062	-.105	.067	-.064
L1M6	.214*	.159	.335**	.075	.105	.213*	-.032	-.043	.037	.127	-.045	.018	-.114
L1M9	.391**	.222*	.386**	.196*	.295**	.295**	.032	.245*	-.110	.008	.005	.019	-.030
L1PHL	.414**	.482**	.219*	.128	.399**	.308**	.044	.109	-.148	-.030	-.069	-.049	-.038
L1PHR	.423**	.448**	.234*	.172	.388**	.300**	-.120	-.051	-.103	-.116	-.083	-.110	-.071
L1M10	.245*	.076	.213*	.065	.047	.039	.524**	.526**	.149	.364**	.359**	.412**	.283**
L1M11	.087	-.058	.161**	.161	-.020	-.031	.425**	.507**	.085	.242*	.344**	.307**	.260**

	C7M2	C7M1	C7M6	C7M9	C7PHL	C7PHR	C7M10	C7M11	C7SPL	C7IFLCR	C7IFLCA	C7IFRCR	C7IFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
L1SPL	.388**	.393**	.358*	.189	.218	.195	-.015	.271	.064	.087	.129	.105	.097
L1TPW	.135	.170	.166	-.096	.103	.191	.188	.108	.338	.164	.163	.042	.293
L1IFLCR	.087	.012	.220*	.167	-.131	-.055	.311**	.247*	.296*	.541**	.550**	.477**	.465**
L1IFLCA	.143	.044	.104	.082	-.022	-.106	.423**	.347**	.232	.512**	.586**	.569**	.460**
L1IFRCR	.072	.018	-.004	.180	-.134	-.090	.213*	.102	.178	.374**	.404**	.330**	.369**
L1IFRCA	.189	.067	.139	.168	-.036	-.108	.446**	.362**	.362**	.462**	.529**	.518**	.396**
L5M2	.507**	.427**	.152	.029	.154	.085	.012	.060	-.054	.062	-.031	.049	-.006
L5M1	.405**	.350**	.218*	-.044	.187	.112	.104	.170	.031	.079	-.026	.142	-.035
L5M6	.299**	.279**	.272**	.125	.186	.272**	-.043	.013	.038	.133	-.086	.154	-.054
L5M9	.276**	.278**	.379**	.498**	.225*	.253**	.134	.031	.073	.037	.173	.133	.059
L5PHL	.344**	.400**	.166	.053	.304**	.296**	.216*	.104	-.126	.093	.115	.010	.043
L5PHR	.315**	.317**	.107	.022	.255*	.250*	.346**	.150	.108	.143	.019	.096	.063
L5M10	.094	-.057	.136	.042	.121	-.012	.265*	.322**	-.032	.145	.141	.304**	.136
L5M11	.213*	.099	.367**	.224*	.083	.107	.309**	.344**	-.044	.320**	.461**	.240*	.358**
L5SPL	.208	.230	.030	.049	.140	.143	-.030	-.007	.064	-.132	-.129	.003	-.232
L5TPW	.123	.077	.089	-.039	-.135	-.164	-.033	.115	-.091	-.009	-.070	.014	-.195
L5IFLCR	.253*	.108	.161	.099	.053	.031	.285**	.322**	.040	.335**	.443**	.386**	.465**
L5IFLCA	.033	-.028	.143	.003	.030	-.007	.232*	.454**	-.074	.206	.245*	.351**	.304**
L5IFRCR	.142	.098	.097	.090	-.047	.015	.409**	.455**	-.002	.505**	.562**	.544**	.611**
L5IFRCA	.135	.178	.168	.131	.009	-.028	.241*	.424**	.008	.331**	.263*	.433**	.405**
FMM16	.015	-.012	.149	.188	-.201	-.159	.385*	.387*	.169	.253	.326*	.227	.336*
FMM7	-.014	-.140	.040	-.063	-.309*	-.292	.326*	.398**	.467*	.507**	.305	.467**	.353*
HLM1	.345**	.222*	.331**	.045	.081	.100	.268**	.327**	.084	.373**	.341**	.403**	.325**
HCM7	.270**	.227*	.270**	.157	.324**	.226*	.057	.141	-.062	-.013	-.050	.005	-.038
FHBM18	.464**	.325**	.371**	.147	.153	.255**	.268**	.420**	-.007	.234*	.231*	.188*	.234*
FLM1	.332**	.266**	.220*	.018	.067	.107	.102	.321**	-.135	.293**	.203*	.163	.215*
FCM8	.300**	.214*	.365**	.111	.171	.236**	.184	.345**	-.117	.001	.085	-.036	-.006
BIWM2	.080	-.148	.366**	.111	.143	.276*	.090	.343**	-.010	.078	.219	.112	.121

	T1M2	T1M1	T1M6	T1M9	T1PHL	T1PHR	T1M10	T1M11	T1SPL	T1TPW	T1IFLCR	T1IFLCA	T1IFRCR
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
C3M2	,550**	.617**	,323**	,340**	,330**	,300**	,157	,214*	,510**	,429**	,031	,170	,034
C3M1	,459**	.501**	,305**	,210*	,227*	,227*	,092	,253**	,453**	,373**	,078	,103	-,014
C3M6	,185	,135	,674**	,233*	,303**	,326**	-,045	,107	,178	,190	-,295**	-,093	-,113
C3M9	,097	,101	,323**	,345**	,241*	,161	,079	,134	,174	,292**	,069	,029	,121
C3PHL	,440**	,355**	,323**	,251*	,543**	,468**	,088	-,004	,468**	,431**	-,123	,094	-,016
C3PHR	,410**	,391**	,340**	,299**	,478**	,420**	,018	-,020	,319*	,437**	-,056	,116	,033
C3M10	,004	,075	,023	-,110	-,140	-,054	,563**	,352**	,150	,118	,450**	,406**	,420**
C3M11	,279**	,274**	,173	,241*	-,071	,038	,479**	,465**	,203	,356**	,297**	,347**	,215*
C3TPW	,266*	,293*	,251*	,241	-,017	,132	,359**	,310*	,431**	,477**	,185	,260*	,157
C3IFLCR	,105	,061	-,121	,140	-,096	-,015	,396**	,247*	-,017	,059	,606**	,426**	,369**
C3IFLCA	,142	,121	-,063	,024	,074	,067	,436**	,080	,157	,205	,360**	,422**	,250*
C3IFRCR	,125	,106	-,190	,013	-,072	-,064	,420**	,181	,046	,139	,480**	,462**	,338**
C3IFRCA	,089	,065	-,181	,165	,066	,039	,437**	,159	,150	,125	,578**	,462**	,410**
C7M2	,723**	,602**	,200*	,242**	,477**	,408**	,265**	,090	,338**	,424**	,237*	,275**	,185
C7M1	,708**	,610**	,092	,141	,523**	,452**	,190	-,106	,343**	,475**	,170	,222*	,090
C7M6	-,002	,109	,751**	,297**	,045	,102	,026	,254**	,177	,199	-,210*	,013	-,039
C7M9	,135	,124	,357**	,426**	,293**	,233*	,104	,019	,362**	,241*	-,238*	-,024	-,026
C7PHL	,363**	,320**	,084	,018	,424**	,424**	-,026	,045	,301*	,112	,132	,001	,032
C7PHR	,333**	,270**	,188	,114	,467**	,464**	,030	,063	,187	,286**	,073	,010	,049
C7M10	,281**	,241*	-,021	-,032	,000	,051	,751**	,335**	,030	,233*	,559**	,548**	,609**
C7M11	,045	,056	,154	,224*	-,198*	-,151	,352**	,732**	,025	,221*	,234*	,264**	,220*
C7SPL	,233*	,300*	,183	,178	,366**	,110	,203	-,073	,694**	,352**	,062	,136	,207
C7IFLCR	,172	,094	-,087	-,071	-,077	,055	,359**	,008	-,057	-,029	,574**	,421**	,371**
C7IFLCA	,231*	,160	,003	-,064	,038	,140	,562**	,143	,124	,299**	,613**	,615**	,440**
C7IFRCR	,172	,102	-,176	-,094	-,160	-,143	,438**	,111	-,125	-,077	,468**	,338**	,348**
C7IFRCA	,225*	,236*	,083	,049	,079	,175	,535**	,226*	,126	,284**	,545**	,639**	,585**
T1M2	1	,723**	,163	,264**	,539**	,514**	,337**	-,139	,400**	,418**	,186*	,253**	,174
T1M1	,651**	1	,257**	,151	,481**	,436**	,234*	-,131	,367**	,446**	,078	,229*	,048
T1M6	,141	,087	1	,314**	,297**	,280**	,135	,180	,198	,356**	-,192*	,059	-,055
T1M9	,304**	,207*	,121	1	,297**	,246**	,096	,103	,176	,346**	,030	,035	,107
T1PHL	,453**	,512**	,292**	,276**	1	,783**	,075	-,341**	,298**	,386**	-,115	,121	-,025
T1PHR	,510**	,511**	,225*	,216*	,790**	1	,112	-,251**	,249*	,354**	-,045	,142	-,032
T1M10	,250**	,047	-,053	,199*	,128	,125	1	,291**	,193	,448**	,524**	,606**	,563**
T1M11	,101	-,046	,065	,134	-,179	-,223*	,460**	1	-,054	,189	,306**	,276**	,269**
T1SPL	,175	,054	,101	-,039	,070	,049	-,003	-,062	1	,440**	,097	,175	,120
T1TPW	,220*	,023	,211*	,114	,024	,055	,128	,446**	,369*	1	,122	,280**	,159

	T1M2	T1M1	T1M6	T1M9	T1PHL	T1PHR	T1M10	T1M11	T1SPL	T1TPW	T1IFLCR	T1IFLCA	T1IFRCR
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
T1IFLCR	.065	.074	.001	-.032	-.143	-.084	.377**	.215*	.098	.009	1	.582**	.699**
T1IFLCA	.170	.091	.069	.053	.048	.055	.504**	.159	-.092	-.153	.582**	1	.593**
T1IFRCR	.138	.135	.153	.034	-.035	-.027	.456**	.334**	.243	.057	.699**	.593**	1
T1IFRCA	.181	.128	.099	.065	.080	.135	.521**	.223*	-.102	-.083	.502**	.788**	.623**
T6M2	.566**	.413**	.158	.169	.296**	.243*	.189	.230*	.292*	.343**	.072	.011	.100
T6M1	.459**	.330**	.173	.135	.206*	.183	.146	.156	.288	.246*	-.042	-.095	.032
T6M6	.296**	.143	.579**	.204*	.293**	.212*	.095	.074	.173	.319**	.022	.167	.219*
T6M9	.325**	.172	.351**	.495**	.333**	.282**	-.059	.068	.153	.219	-.235*	-.156	.008
T6PHL	.370**	.289**	.265**	.089	.380**	.292**	.233*	.188	.428**	.293*	.051	-.133	.073
T6PHR	.297**	.311**	.274**	.124	.371**	.226*	.226*	.221*	.270	.297**	.149	-.120	.142
T6M10	-.070	-.128	.003	.045	-.159	-.166	.549**	.432**	.108	.109	.260*	.447**	.368**
T6M11	.191	.096	-.008	.245*	-.028	.102	.339**	.408**	-.124	-.043	.167	.198	.191
T6SPL	.013	.175	.165	-.281	.126	.213	-.151	-.169	.383	-.141	-.131	-.132	-.074
T6TPW	.199	.022	.210	.195	.136	.117	.186	.139	.307	.280*	-.076	-.085	.121
T6IFLCA	.015	-.009	.066	.105	-.070	.000	.064	.068	-.227	-.223	.168	.133	.094
T6IFRCA	.127	.183	.030	-.025	.062	.051	.123	.118	-.120	-.123	.213	.303**	.223*
T10M2	.463**	.409**	.171	.098	.090	.140	.233*	.247**	.078	.243*	.094	.096	.143
T10M1	.354**	.395**	.056	.059	.187	.114	.071	.206*	.317**	.258*	-.033	-.136	.071
T10M6	.269**	.258**	.455**	.119	.190	.085	.137	.094	.267	.327**	.139	.155	.309**
T10M9	.248**	.138	.407**	.456**	.312**	.245**	.064	.121	.008	.276*	-.133	-.017	.046
T10PHL	.328**	.361**	.195*	.182	.362**	.281**	.283**	.338**	.068	.241*	.045	-.073	.087
T10PHR	.262**	.412**	.247*	.136	.348**	.299**	.244*	.203*	.110	.211	.131	-.028	.182
T10M10	.110	-.030	-.002	.074	-.054	.038	.660**	.568**	.118	.146	.248*	.303**	.325**
T10M11	.238*	.038	.157	.236*	.021	.053	.504**	.473**	.034	.089	.247*	.298**	.373**
T10SPL	.438**	.306*	.237	.184	.251	.272	.194	.326*	.455*	.445*	.128	-.029	.288
T10TPW	.108	.036	.178	-.005	.072	.119	.209	.248*	.550**	.331**	-.003	-.068	.173
T10IFLCA	.097	-.083	-.016	.014	-.138	-.098	.351**	.236*	-.072	-.024	.311**	.578**	.250*
T10IFRCA	.152	-.104	.110	-.014	-.064	-.015	.419**	.306**	.012	.088	.354**	.627**	.354**
L1M2	.562**	.483**	.148	.043	.165	.198*	-.040	.085	.253	.357**	.046	-.081	.069
L1M1	.557**	.512**	.297**	.087	.254**	.280**	-.092	.002	.317*	.136	-.102	-.076	.037
L1M6	.261**	.123	.419**	.088	.173	.097	.010	-.026	.331*	.275*	.026	.013	.080
L1M9	.370**	.188	.418**	.369**	.268**	.185	-.002	.219*	.129	.327**	-.247*	-.154	-.072
L1PHL	.435**	.449**	.217*	.213*	.363**	.426**	.063	.113	.170	.190	.007	-.194	.025
L1PHR	.478**	.479**	.237*	.223*	.521**	.487**	.020	-.062	.067	.209	-.127	-.180	-.093
L1M10	.181	.151	.085	-.020	-.010	-.018	.532**	.568**	.157	.188	.339**	.322**	.373**
L1M11	.068	-.028	.256**	.181	.005	-.019	.494**	.514**	-.155	.113	.106	.305**	.241*

	T1M2	T1M1	T1M6	T1M9	T1PHL	T1PHR	T1M10	T1M11	T1SPL	T1TPW	T1IFLCR	T1IFLCA	T1IFRCR
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
L1SPL	.381**	.329*	.312*	.198	.316*	.107	-.056	.334*	.267	.396*	-.026	.015	.104
L1TPW	.129	.194	.076	-.077	.203	.236	.201	.087	.182	.359*	.096	.091	.305*
L1IFLCR	-.048	-.044	.307**	.012	-.039	-.040	.306**	.204*	-.072	-.028	.513**	.573**	.496**
L1IFLCA	.071	.019	.055	-.095	-.164	-.087	.449**	.378**	.040	.031	.503**	.575**	.504**
L1IFRCR	-.070	-.063	.149	-.056	-.056	-.066	.208	.231*	-.039	-.075	.498**	.532**	.427**
L1IFRCA	.081	.013	.149	-.096	-.083	-.063	.436**	.393**	.146	.023	.509**	.571**	.484**
L5M2	.553**	.446**	.180	.209*	.228*	.146	.094	.188	.071	.280*	.021	.061	.099
L5M1	.414**	.357**	.188	.081	.060	.121	.143	.265**	.502**	.304**	.018	-.018	.204
L5M6	.238*	.370**	.205*	.253*	.321**	.169	-.093	.010	.096	.168	.080	-.034	.132
L5M9	.342**	.203*	.346**	.488**	.342**	.251**	.186	-.020	.029	.122	-.031	.070	.127
L5PHL	.396**	.347**	.175	.106	.355**	.321**	.234*	.055	.010	.068	-.008	.016	.014
L5PHR	.377**	.332**	.145	.039	.261**	.205*	.299**	.060	.166	.200	.090	.030	.108
L5M10	.035	-.068	.146	.048	-.044	-.033	.148	.343**	.360*	.282*	.116	-.010	.229*
L5M11	.293**	.074	.382**	.253*	.159	.117	.311**	.248*	-.179	.038	.221*	.441**	.210*
L5SPL	.139	.078	.044	-.058	.087	-.160	.008	.270	.116	.249	-.339*	-.121	-.107
L5TPW	.204	.010	.040	-.017	-.067	.101	-.008	.027	-.072	.392**	-.039	-.084	-.011
L5IFLCR	.215*	.035	.268**	.137	.041	.056	.264*	.244*	.071	.059	.358**	.427**	.359**
L5IFLCA	-.002	-.072	.184	.015	.022	.002	.255*	.284**	.099	.186	.207*	.271**	.319**
L5IFRCR	.172	-.009	.242*	.074	.062	.081	.397**	.315**	.228	.123	.562**	.556**	.442**
L5IFRCA	.071	.016	.234*	.053	.060	.022	.209	.279**	.257	.179	.224*	.261*	.286**
FMM16	.183	-.097	.176	.116	-.092	.045	.404**	.196	-.037	.351*	.297	.349*	.172
FMM7	.097	-.039	.065	.004	-.267	-.131	.207	.424**	.125	.162	.376*	.271	.300*
HLM1	.320**	.139	.384**	.187	.157	.134	.313**	.303**	.334*	.424**	.144	.207*	.297**
HCM7	.313**	.260**	.335**	.265**	.305**	.187*	.036	.116	.161	.306**	-.232*	-.123	-.024
FHBM18	.481**	.293**	.354**	.289**	.335**	.254**	.356**	.391**	.186	.407**	.138	.160	.310**
FLM1	.355**	.233*	.254*	.111	.241*	.218*	.124	.233*	.292	.240*	.069	-.003	.170
FCM8	.358**	.188*	.324**	.186*	.306**	.180*	.227*	.359**	.185	.441**	-.134	-.080	.019
BIWM2	.101	-.017	.280*	.260*	.204	.065	.332*	.386**	.112	.414**	.122	.106	.243

	T1IFRCA	T6M2	T6M1	T6M6	T6M9	T6PHL	T6PHR	T6M10	T6M11	T6SPL	T6TPW	T6IFLCA	T6IFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
C3M2	.107	.526**	.321**	.380**	.469**	.464**	.527**	.208	.236*	.000	.419**	.104	-.005
C3M1	.043	.401**	.274**	.380**	.448**	.361**	.381**	.129	.174	.234	.464**	.183	-.019
C3M6	-.074	.366**	.230*	.438**	.423**	.424**	.360**	.006	.034	-.041	.271*	.063	.081
C3M9	.068	.216*	.154	.047	.245*	.294**	.289**	.233*	.138	-.347	.147	.106	.017
C3PHL	-.050	.355**	.248*	.259*	.273**	.495**	.477**	.041	.041	-.126	.432**	-.032	-.077
C3PHR	.019	.399**	.339**	.313**	.219*	.512**	.528**	.150	.036	.092	.379**	-.027	.019
C3M10	.421**	.018	-.145	-.013	-.113	-.001	.032	.282*	.251*	-.088	-.046	.268*	.174
C3M11	.407**	.285**	.052	.212*	.154	.264*	.273**	.465**	.422**	-.229	.320*	.243*	.154
C3TPW	.275*	.424**	.223	.282*	.188	.509**	.565**	.354**	.044	-.124	.533**	.245	.305*
C3IFLCR	.419**	-.053	-.152	-.009	-.150	-.011	.035	.162	.162	.020	-.200	.253*	.203
C3IFLCA	.410**	.086	-.169	.198	.126	-.041	.048	.158	.081	.129	.033	.187	.142
C3IFRCR	.381**	-.009	-.158	-.134	-.093	-.109	.071	.110	.063	-.119	-.066	.135	.077
C3IFRCA	.444**	.050	-.163	.120	.072	-.008	.084	.131	.101	-.222	.002	.273*	.224*
C7M2	.244*	.490**	.282**	.454**	.414**	.380**	.318**	.154	.270**	.323	.338**	.142	.115
C7M1	.188	.537**	.329**	.394**	.357**	.332**	.314**	.160	.162	-.006	.350**	-.043	-.091
C7M6	.045	.276**	.250*	.478**	.401**	.224*	.269**	.207*	.148	.128	.284*	.294**	.077
C7M9	.059	.364**	.332**	.354**	.345**	.501**	.435**	.183	.133	-.044	.368**	.259*	.132
C7PHL	.002	.299**	.209*	.211*	.203*	.400**	.390**	.069	.083	.320	-.026	-.008	.048
C7PHR	-.011	.286**	.184	.267**	.256**	.315**	.235*	.084	.145	.290	.121	.042	.114
C7M10	.537**	.200*	.003	.078	-.001	.014	-.036	.333**	.453**	-.145	.057	.144	.105
C7M11	.238*	.195*	.117	.192	.082	.159	.115	.235*	.471**	-.043	.213	.260*	.193
C7SPL	.159	.260*	-.086	.287*	.285*	.250	.213	.077	-.076	-.060	.276	.103	.031
C7IFLCR	.362**	-.025	-.057	-.117	-.196	-.109	-.075	.036	.162	-.083	.025	.047	-.094
C7IFLCA	.578**	.187	-.214*	.223*	.020	.112	.035	.165	.169	-.043	.134	.090	-.042
C7IFRCR	.307**	.058	.080	-.111	-.230*	-.087	-.089	.059	.228*	-.081	-.188	.084	.050
C7IFRCA	.674**	.207*	-.098	.164	-.029	.158	.070	.314**	.228*	-.138	.154	.165	.115
T1M2	.285**	.558**	.374**	.407**	.359**	.489**	.462**	-.018	.137	.220	.382**	.026	-.052
T1M1	.213*	.414**	.285**	.345**	.432**	.382**	.337**	-.003	.150	.233	.443**	-.068	-.181
T1M6	.071	.236*	.085	.562**	.408**	.338**	.282**	.028	.035	-.105	.318**	.154	.055
T1M9	.005	.312**	.262**	.334**	.364**	.371**	.379**	.086	.032	-.151	.294*	.168	.085
T1PHL	.133	.287**	.135	.375**	.405**	.444**	.429**	-.088	-.086	-.077	.274*	-.029	-.079
T1PHR	.177	.293**	.111	.314**	.279**	.491**	.475**	.003	-.071	-.028	.304*	-.112	-.093
T1M10	.623**	.220*	.060	.167	.037	.147	.132	.393**	.301**	-.050	.222	.206	.148
T1M11	.186*	.126	.092	.152	.162	.085	.059	.399**	.478**	-.097	.055	.229*	.180
T1SPL	.107	.425**	.140	.303*	.325**	.479**	.488**	.254*	.120	-.214	.505**	.127	.075
T1TPW	.253*	.447**	.156	.529**	.440**	.431**	.456**	.231*	.143	-.382*	.449**	.186	.043

	T1lFRCA	T6M2	T6M1	T6M6	T6M9	T6PHL	T6PHR	T6M10	T6M11	T6SPL	T6TPW	T6lFLCA	T6lFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
T1lFLCR	,554**	,034	-,130	-,044	-,128	-,060	-,062	,137	,249*	-,116	-,122	,142	,085
T1lFLCA	,791**	,147	-,001	,178	,089	,085	,088	,307**	,241*	-,089	,078	,276**	,190
T1lFRCR	,574**	,085	,016	-,032	-,060	,013	-,043	,242*	,224*	-,161	-,050	,219*	,152
T1lFRCA	1	,189	-,002	,089	,048	,089	,074	,344**	,263**	,030	,072	,273**	,224*
T6M2	,102	1	,728**	,416**	,436**	,582**	,572**	,240*	,161	,025	,400**	,068	-,021
T6M1	-,019	,739**	1	,155	,320**	,375**	,381**	,222*	,186*	,141	,298*	,110	,127
T6M6	,245*	,357**	,223*	1	,564**	,392**	,371**	,031	,062	,018	,365**	,158	,108
T6M9	-,126	,157	,216*	,404**	1	,309**	,313**	,032	,137	,103	,267*	,091	-,007
T6PHL	-,001	,484**	,360**	,214*	,234*	1	,828**	,063	-,089	,045	,334**	,162	,124
T6PHR	,045	,335**	,252**	,266**	,131	,711**	1	,137	-,040	-,028	,321**	,106	,073
T6M10	,474**	,079	-,022	-,057	-,096	-,023	-,032	1	,530**	-,234	,299*	,188	,210*
T6M11	,218*	,006	-,012	-,050	,190*	-,032	-,023	,360**	1	,018	,271*	,154	,236*
T6SPL	-,120	-,174	-,033	-,174	-,067	-,113	-,181	-,262	,044	1	-,060	,037	,006
T6TPW	,032	,166	,157	,267*	,261*	,286**	,097	,070	,257*	,163	1	,043	,063
T6lFLCA	,122	,110	,051	-,129	-,040	-,033	-,083	,124	,218*	,023	-,081	1	,721**
T6lFRCA	,259*	,105	,091	-,003	-,062	-,033	,113	-,026	,128	-,090	-,095	,575**	1
T10M2	,156	,595**	,629**	,265**	,212*	,288**	,136	,060	,137	-,063	-,060	,122	,013
T10M1	,040	,595**	,598**	,191*	,167	,402**	,267**	,069	,065	,094	,145	,045	,092
T10M6	,226*	,365**	,185	,622**	,353**	,245*	,257**	,101	-,015	,087	,312**	,024	,036
T10M9	,000	,171	,236*	,408**	,754**	,221*	,145	-,051	,180	,094	,224*	,119	-,003
T10PHL	,000	,470**	,474**	,280**	,213*	,548**	,594**	-,007	,188	,032	,095	,007	,134
T10PHR	,030	,451**	,442**	,309**	,177	,512**	,545**	-,004	,200*	,029	,078	,039	,117
T10M10	,365**	,237*	,154	,040	,017	,154	,163	,634**	,500**	-,186	,125	,058	-,001
T10M11	,338**	,246*	,133	,097	,262**	,150	,101	,415**	,744**	-,131	,274*	,338**	,220*
T10SPL	,007	,210	,147	-,045	,137	,406**	,114	,108	,337*	,530**	,531**	,133	,045
T10TPW	-,027	,147	,116	,341**	,118	,208	,138	,038	,088	,342*	,514**	-,174	-,092
T10lFLCA	,467**	,016	-,049	,100	-,149	-,164	-,002	,305**	,237*	-,056	-,065	,304**	,384**
T10lFRCA	,574**	,044	-,010	,205*	-,066	-,075	,142	,386**	,210*	-,143	-,108	,104	,224*
L1M2	-,117	,647**	,608**	,243*	,136	,303**	,189	-,050	,006	-,224	,091	,019	,093
L1M1	-,106	,501**	,581**	,339**	,216*	,298**	,204*	-,069	-,007	,049	,125	,104	,170
L1M6	-,001	,389**	,385**	,544**	,450**	,168	,148	-,017	-,072	-,060	,277*	,121	,183
L1M9	-,156	,287**	,220*	,419**	,591**	,248*	,184	-,052	,049	,059	,212	,119	-,015
L1PHL	-,033	,418**	,386**	,245*	,248**	,370**	,384**	-,044	,154	,042	,130	,003	,202
L1PHR	-,072	,363**	,260**	,273**	,313**	,332**	,238*	-,175	-,033	,174	,058	-,083	,094
L1M10	,354**	,215*	,140	,033	,021	,134	,124	,573**	,449**	,007	,115	,037	,017
L1M11	,286**	,156	,076	,228*	,171	,150	,149	,348**	,475**	-,217	,221*	,040	,117

	T1lFRCA	T6M2	T6M1	T6M6	T6M9	T6PHL	T6PHR	T6M10	T6M11	T6SPL	T6TPW	T6lFLCA	T6lFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
L1SPL	.003	.304*	.214	.364*	.388**	.320*	.297*	-.106	.221	.379	.299	.122	.075
L1TPW	.211	.161	-.031	-.023	-.049	.143	.230	.497**	.192	.384	-.017	.133	-.133
L1lFLCR	.430**	-.139	-.098	.200*	-.117	-.114	-.053	.292**	.204*	.028	.009	.206	.127
L1lFLCA	.457**	.047	.042	.048	-.123	.036	-.025	.471**	.354**	.010	.081	.126	.209
L1lFRCR	.411**	.033	.020	.072	-.126	.047	-.019	.318**	.141	.174	.059	.224*	.150
L1lFRCA	.434**	.113	.166	.106	-.055	.127	.114	.451**	.360**	-.041	.136	.126	.198
L5M2	.092	.487**	.379**	.334**	.199*	.283**	.108	-.078	-.051	-.111	.158	-.026	.059
L5M1	.079	.453**	.507**	.252*	.232*	.250*	.075	.144	.039	.095	.150	-.028	.017
L5M6	.013	.289**	.261**	.322**	.350**	.198	.186	-.058	.072	-.150	.029	.175	.228*
L5M9	.047	.215*	.274**	.397**	.451**	.198*	.194*	.058	.131	-.265	.276*	.084	.096
L5PHL	.007	.297**	.253*	.226*	.279**	.389**	.290**	.104	.215*	-.149	.125	.034	.228*
L5PHR	.030	.356**	.344**	.168	.207*	.419**	.236*	.035	.077	.134	.206	.077	.099
L5M10	.065	.055	.009	-.010	-.028	.210*	.163	.401**	.104	-.139	.029	.032	.019
L5M11	.313**	.101	.016	.232*	.263**	.111	.064	.317**	.430**	-.259	.105	.177	.160
L5SPL	-.156	.461**	.309*	.206	.122	.244	.152	.081	-.043	-.154	.419**	.077	-.077
L5TPW	.178	.076	-.027	-.128	.005	-.136	-.170	.118	.085	.089	.091	.078	.132
L5lFLCR	.403**	.126	-.006	.155	.093	-.015	.054	.269**	.284**	.008	.106	.172	.288**
L5lFLCA	.199	.078	-.004	.013	.023	.054	.038	.271**	.010	-.005	.070	.015	.168
L5lFRCR	.499**	.123	.047	.133	-.038	.062	.214*	.309**	.231*	-.143	.055	.182	.272*
L5lFRCA	.219*	.161	.150	.038	.003	.077	.119	.310**	.023	-.019	.034	-.016	.132
FMM16	.159	-.037	-.238	.305	-.094	.046	.080	.196	.228	-.291	.091	.176	.062
FMM7	.118	.089	-.124	.251	-.074	.050	.065	.316*	.277	-.415	.129	.077	-.085
HLM1	.175	.327**	.178	.530**	.328**	.281**	.196	.095	.188	.027	.245*	.009	.054
HCM7	-.078	.332**	.317**	.392**	.476**	.373**	.257**	.004	-.003	.220	.259*	-.062	-.089
FHBM18	.162	.438**	.319**	.584**	.508**	.314**	.319**	.075	.243**	-.164	.332**	.099	.171
FLM1	-.007	.457**	.311**	.394**	.351**	.368**	.228*	.054	.172	-.094	.151	.018	.105
FCM8	-.008	.382**	.203*	.459**	.389**	.378**	.300**	.075	.121	.003	.233*	.024	-.003
BIWM2	-.021	.129	-.001	.488**	.301*	.251*	.232	.200	.222	.157	.402**	-.078	-.114

	T10M2	T10M1	T10M6	T10M9	T10PHL	T10PHR	T10M10	T10M11	T10SPL	T10TPW	T10IFLCA	T10IFRCA	L1M2
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
C3M2	,478**	,377**	,441**	,450**	,346**	,414**	,267**	,164	,463**	,281*	,147	,084	,511**
C3M1	,375**	,283**	,373**	,349**	,335**	,342**	,160	,039	,263	,196	,145	,062	,362**
C3M6	,223*	,117	,460**	,400**	,227*	,315**	,064	-,002	,366*	,236	-,116	-,050	,103
C3M9	-,015	-,018	,141	,282**	,050	,177	,155	,072	,008	,024	-,076	,056	,236*
C3PHL	,120	,085	,216*	,279**	,203*	,233*	,046	-,117	,336*	,137	-,036	-,090	,306**
C3PHR	,108	,038	,432**	,279**	,259**	,288**	,028	-,122	,323*	,149	,039	,037	,312**
C3M10	,048	-,065	-,018	-,033	,034	,077	,461**	,335**	-,107	,286*	,400**	,302**	-,063
C3M11	,352**	,231*	,144	,343**	,161	,187	,569**	,548**	,273	,371**	,339**	,256*	,285**
C3TPW	,135	,099	,289*	,271*	,081	,126	,236	,229	,346	,543**	,312*	,357**	,371**
C3IFLCR	-,071	-,008	,107	-,124	-,060	-,080	,219*	,176	,134	,255*	,320**	,379**	-,091
C3IFLCA	,059	-,013	,179	,077	,084	,168	,144	,207*	,250	,308*	,367**	,417**	,033
C3IFRCR	-,033	,001	-,030	-,068	-,028	-,025	,165	,142	-,020	,188	,336**	,289**	,035
C3IFRCA	-,001	-,103	,066	,044	,027	,132	,146	,184	,008	,232	,344**	,362**	,021
C7M2	,486**	,334**	,344**	,281**	,328**	,359**	,160	,190*	,374*	,107	,301**	,158	,477**
C7M1	,431**	,261**	,278**	,263**	,273**	,285**	,154	,114	,165	-,025	,180	,032	,386**
C7M6	,177	,194*	,534**	,418**	,183	,187	,123	,175	,527**	,352**	-,036	-,007	,072
C7M9	,161	,110	,287**	,382**	,268**	,344**	,141	,111	,269	-,033	-,078	-,031	,147
C7PHL	,208*	,207*	,182	,088	,273**	,183	,005	,040	,423**	-,013	,160	,087	,186
C7PHR	,157	,114	,198*	,112	,165	,154	,015	,014	,296	,092	,174	,139	,152
C7M10	,209*	,035	,070	,066	,030	,164	,560**	,388**	-,134	,125	,442**	,349**	,093
C7M11	,159	,001	,086	,210*	,126	-,028	,423**	,442**	-,056	,169	,325**	,207*	,027
C7SPL	,207	,210	,213	,341**	,214	,313*	,192	,109	,355*	,251	,154	,073	,266*
C7IFLCR	-,031	,120	-,003	-,171	-,100	-,059	,098	,152	,016	-,019	,077	,090	-,086
C7IFLCA	,153	,068	,118	,030	-,052	,057	,205*	,326**	-,006	,126	,414**	,401**	,100
C7IFRCR	,009	,146	-,024	-,209*	-,035	-,060	,271**	,182	-,021	,004	,178	,173	-,008
C7IFRCA	,111	,016	,149	,020	-,023	,016	,317**	,316**	,156	,092	,509**	,432**	,116
T1M2	,510**	,376**	,404**	,293**	,342**	,361**	,058	-,028	,264	-,034	,025	-,134	,468**
T1M1	,421**	,387**	,328**	,317**	,316**	,307**	,127	,044	,312*	,113	,140	-,022	,419**
T1M6	,128	,070	,590**	,461**	,188*	,159	,031	,067	,380*	,342**	-,015	-,026	,067
T1M9	,170	,080	,374**	,392**	,138	,204*	-,091	,025	,033	,092	-,083	-,139	,118
T1PHL	,173	,063	,243*	,338**	,380**	,475**	-,033	-,217*	,159	-,189	,021	-,086	,212*
T1PHR	,199*	,064	,213*	,294**	,407**	,405**	,006	-,157	,263	-,141	-,110	-,145	,102
T1M10	,237*	,057	,274**	,130	,155	,240*	,557**	,400**	,017	,319**	,448**	,285**	,080
T1M11	,207*	,026	,047	,203*	,097	-,044	,412**	,492**	,010	,283*	,351**	,234*	,051
T1SPL	,260*	,263*	,392**	,459**	,409**	,385**	,166	,149	,284	,022	-,014	-,078	,250*
T1TPW	,416**	,171	,532**	,514**	,373**	,428**	,218*	,141	,216	,293*	,218*	-,007	,458**

	T10M2	T10M1	T10M6	T10M9	T10PHL	T10PHR	T10M10	T10M11	T10SPL	T10TPW	T10IFLCA	T10IFRCA	L1M2
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
T1IFLCR	.077	.022	-.016	-.172	-.073	-.079	.223*	.295**	-.178	.136	.361**	.295**	-.006
T1IFLCA	.082	.028	.183	.087	.119	.126	.246**	.218*	-.014	.180	.376**	.278**	.052
T1IFRCR	.010	-.002	.056	-.037	-.041	-.046	.272**	.259**	-.231	.147	.345**	.245*	.029
T1IFRCA	.101	.066	.151	.110	.090	.137	.354**	.280**	.089	.079	.365**	.345**	.054
T6M2	.633**	.434**	.434**	.441**	.387**	.395**	.155	.172	.447**	.128	.039	-.016	.527**
T6M1	.411**	.442**	.224*	.205*	.212*	.171	.023	.026	.323*	-.059	-.094	-.167	.336**
T6M6	.474**	.187	.694**	.607**	.434**	.421**	.128	.173	.479**	.228	.126	.051	.193*
T6M9	.485**	.273**	.532**	.704**	.463**	.454**	.023	.087	.349*	.025	-.066	-.124	.354**
T6PHL	.386**	.186	.434**	.399**	.490**	.450**	.113	.005	.329*	.069	.065	.015	.336**
T6PHR	.455**	.245**	.434**	.426**	.528**	.505**	.132	.033	.396**	.044	.067	-.051	.313**
T6M10	.121	.158	.135	.197*	.141	.247*	.628**	.566**	.138	.107	.219*	.157	.091
T6M11	.220*	.223*	.022	.251**	.076	.120	.558**	.662**	.167	-.077	.217*	.106	.124
T6SPL	.088	.456**	.100	-.168	.033	.053	-.109	-.078	.476*	.102	-.031	.142	-.125
T6TPW	.117	-.064	.392**	.483**	.235	.371**	.216	.145	.044	.444**	.002	.074	.402**
T6IFLCA	.091	.017	.334**	.096	.142	.197	.134	.077	.081	.091	.292**	.283**	.030
T6IFRCA	-.084	-.108	.154	.030	.104	.116	.068	.156	.209	.076	.252*	.259*	-.063
T10M2	1	.652**	.315**	.446**	.605**	.567**	.325**	.271**	.402**	.075	.218*	.043	.516**
T10M1	.672**	1	.152	.145	.340**	.282**	.255**	.282**	.480**	.011	.075	-.007	.457**
T10M6	.266**	.185*	1	.545**	.297**	.358**	.086	.107	.442**	.350**	.070	.020	.187*
T10M9	.403**	.260**	.340**	1	.535**	.538**	.216*	.219*	.396**	.093	-.074	-.110	.318**
T10PHL	.618**	.506**	.184*	.417**	1	.825**	.278**	.135	.266	-.090	.051	.002	.304**
T10PHR	.587**	.467**	.243**	.383**	.838**	1	.288**	.112	.289*	.013	-.009	-.002	.285**
T10M10	.302**	.234*	.031	.164	.337**	.302**	1	.890**	.072	.206	.408**	.279**	.174
T10M11	.245**	.104	.157	.385**	.263**	.267**	.614**	1	.347*	.265*	.406**	.289**	.064
T10SPL	.156	.265	.157	.182	.064	.164	.085	.239	1	.237	-.024	.090	.290*
T10TPW	-.147	.044	.276**	.052	.047	-.028	.145	.126	.379*	1	.305**	.382**	.190
T10IFLCA	.069	-.070	.119	.084	-.071	-.088	.308**	.297**	.084	.029	1	.741**	.127
T10IFRCA	.160	.072	.164	.091	.063	.045	.527**	.346**	.061	.014	.661**	1	.098
L1M2	.575**	.487**	.317**	.182*	.399**	.361**	.016	.066	.195	.053	-.070	-.006	1
L1M1	.542**	.502**	.339**	.240**	.314**	.319**	-.095	.007	.282*	.012	-.080	-.085	.754**
L1M6	.257**	.263**	.534**	.472**	.210*	.189*	.008	.124	-.056	.221*	.160	.152	.454**
L1M9	.266**	.145	.346**	.663**	.246**	.167	.033	.264**	.223	.169	-.111	.012	.245**
L1PHL	.277**	.382**	.185*	.199*	.462**	.372**	.007	.037	.179	.095	-.048	-.105	.549**
L1PHR	.244**	.271**	.226*	.246**	.414**	.378**	-.158	-.067	.215	.139	-.105	-.157	.522**
L1M10	.292**	.320**	.127	.065	.197*	.233*	.667**	.502**	.136	.096	.204*	.373**	.180*
L1M11	.161	.075	.177	.247**	.201*	.245**	.585**	.622**	.101	-.007	.196*	.401**	.049

	T10M2	T10M1	T10M6	T10M9	T10PHL	T10PHR	T10M10	T10M11	T10SPL	T10TPW	T10IFLCA	T10IFRCA	L1M2
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
L1SPL	.330*	.175	.366**	.397**	.353*	.264	.042	.143	.528**	.149	.093	.055	.282*
L1TPW	-.060	.042	.422**	.007	-.064	.274	.362*	.265	.307	.257	.304*	.433**	.127
L1IFLCR	.127	-.088	.157	.133	.088	.196*	.297**	.309**	.012	-.037	.340**	.450**	.012
L1IFLCA	.214*	.057	.129	.038	.112	.188*	.496**	.400**	.025	.018	.509**	.506**	.059
L1IFRCR	.185	.069	.022	.138	.218*	.333**	.212*	.234*	.153	-.111	.242*	.335**	.071
L1IFRCA	.270**	.162	.152	.150	.219*	.308**	.476**	.423**	.156	.016	.367**	.491**	.176
L5M2	.418**	.291**	.304**	.175	.286**	.224*	-.069	.042	.105	.119	-.089	-.086	.564**
L5M1	.463**	.521**	.362**	.267**	.229*	.118	.114	.121	.243	.199	-.077	.049	.523**
L5M6	.240*	.284**	.331**	.366**	.262**	.326**	.037	.155	.092	.115	.018	-.100	.333**
L5M9	.192*	.130	.261**	.466**	.232*	.170	.083	.244**	.011	.086	.011	.050	.337**
L5PHL	.256**	.195*	.207*	.259**	.303**	.299**	.134	.066	.173	.040	-.036	-.153	.352**
L5PHR	.280**	.265**	.310**	.264**	.373**	.360**	.070	.154	.223	.115	-.206*	-.247*	.277**
L5M10	.046	.054	.109	.038	.149	.042	.311**	.185	.227	.069	.017	.169	.015
L5M11	.192*	.038	.243*	.375**	.159	.161	.357**	.495**	.199	-.069	.278**	.461**	.106
L5SPL	.095	.327*	.220	.083	.144	.028	.038	.061	.263	.408**	.134	-.044	.230
L5TPW	.183	.125	-.113	.174	-.156	-.188	.182	.202	.309	-.039	.124	.136	.100
L5IFLCR	.036	-.020	.198*	.052	.073	.019	.300**	.301**	.066	.164	.231*	.397**	.160
L5IFLCA	.110	-.014	.126	.136	.189	.059	.247*	.163	.128	.023	.229*	.212*	.029
L5IFRCR	.050	-.031	.137	-.002	.062	-.006	.384**	.235*	-.026	.098	.321**	.459**	.080
L5IFRCA	.147	.028	.114	.067	.173	.094	.280**	.155	.113	.119	.268**	.352**	.194*
FMM16	.066	-.016	.195	-.059	-.010	.010	.230	.278	-.172	.346	.259	.297	.197
FMM7	-.006	-.017	.162	-.146	.036	.045	.508**	.425**	-.014	.496**	.201	.303	.056
HLM1	.303**	.190	.491**	.399**	.232*	.225*	.207*	.404**	.260	.305**	.211*	.243*	.370**
HCM7	.374**	.261**	.384**	.478**	.294**	.262**	-.001	.113	.284*	.108	-.071	-.044	.280**
FHBM18	.385**	.315**	.541**	.473**	.308**	.322**	.278**	.351**	.312*	.310**	.208*	.287**	.342**
FLM1	.356**	.334**	.364**	.331**	.294**	.311**	.161	.255**	.353*	.211	.124	.145	.414**
FCM8	.296**	.275**	.468**	.403**	.331**	.304**	.227*	.254**	.449**	.255*	.091	.149	.226**
RIWM2	.027	.159	.536**	.316**	.197	.247*	.191	.296*	.289	.352**	.180	.268*	.120

	L1M1	L1M6	L1M9	L1PHL	L1PHR	L1M10	L1M11	L1SPL	L1TPW	L1IFLCR	L1IFLCA	L1IFRCR	L1IFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
C3M2	,398**	,476**	,293**	,485**	,471**	,204*	,216*	,198	,225	,087	,125	,280**	,234*
C3M1	,314**	,445**	,245**	,442**	,355**	,102	,212*	,298**	,162	,017	,162	,199*	,242*
C3M6	,042	,435**	,515**	,184	,222*	-,020	,086	,278	,471**	-,192	-,140	-,099	,068
C3M9	,136	,138	,213*	,228*	,359**	,033	-,027	,234	-,217	-,128	,004	-,005	,000
C3PHL	,113	,479**	,285**	,379**	,478**	,003	-,002	,315*	,247	-,183	,006	,083	,106
C3PHR	,120	,488**	,222*	,320**	,431**	-,029	,015	,227	,156	-,177	,014	,050	,105
C3M10	,049	-,069	-,119	,056	-,007	,429**	,411**	,116	,031	,427**	,358**	,270*	,295**
C3M11	,215*	,165	,312**	,143	,231*	,544**	,380**	,001	,065	,383**	,318**	,311**	,253*
C3TPW	,250*	,287*	,228	,312*	,424**	,415**	,067	,286	,128	,204	,371**	,226	,363**
C3IFLCR	,004	-,050	-,078	-,077	,012	,377**	,124	,039	-,006	,288**	,268**	,160	,295**
C3IFLCA	,220*	,087	,185	,026	,006	,293**	,146	-,055	,252	,225*	,230*	,110	,209*
C3IFRCR	,138	-,207*	-,088	-,012	,020	,346**	,094	-,081	-,153	,232*	,340**	,124	,329**
C3IFRCA	,076	,050	,085	,053	-,027	,241*	,148	-,058	,000	,265**	,220*	,084	,164
C7M2	,370**	,297**	,329**	,314**	,272**	,201*	,244**	,219	-,044	,042	,217*	,159	,124
C7M1	,309**	,247*	,259**	,228*	,350**	,082	,114	,340*	-,013	,024	,196*	,048	,147
C7M6	,021	,455**	,381**	,312**	,284**	,052	,318**	,269	,252	,055	,009	,184	,161
C7M9	,115	,383**	,473**	,249**	,229*	,065	,075	-,078	,107	-,108	,036	,097	,071
C7PHL	,115	,251*	,228*	,194*	,171	,007	,120	,288	,124	-,234*	-,092	,062	-,111
C7PHR	,202*	,323**	,266**	,232*	,265**	,009	,159	,471**	,111	-,121	,137	,173	,092
C7M10	,124	-,102	,011	-,084	-,125	,588**	,318**	,128	,063	,354**	,388**	,251*	,360**
C7M11	-,115	,026	,129	,157	,079	,379**	,287**	-,173	,068	,201*	,193*	,123	,189
C7SPL	,254*	,409**	,346**	,148	,135	-,007	-,084	,569**	,489**	,021	,062	,124	,193
C7IFLCR	-,083	,013	-,142	-,107	-,081	,110	,129	-,122	-,049	,212*	,102	-,026	,142
C7IFLCA	,065	-,030	,072	,067	,037	,368**	,172	,081	,048	,398**	,427**	,263**	,381**
C7IFRCR	-,058	-,077	-,161	-,117	-,004	,261**	,153	-,351*	-,019	,216*	,039	,032	,091
C7IFRCA	,141	-,062	,085	,041	,084	,366**	,130	,116	,140	,342**	,420**	,241*	,422**
T1M2	,358**	,370**	,277**	,215*	,245**	,152	,161	,230	,186	-,114	,069	,069	,155
T1M1	,511**	,214*	,233*	,211*	,268**	,217*	,159	,278	,303*	,103	,196*	,180	,163
T1M6	,086	,475**	,476**	,283**	,280**	,017	,280**	,281	,181	,020	,118	,133	,210*
T1M9	,074	,281**	,285**	,299**	,245**	,018	,079	-,084	,142	,028	,137	,103	,179
T1PHL	,253**	,217*	,295**	,270**	,299**	-,128	-,092	,338*	,154	-,188	,039	,048	,010
T1PHR	,170	,152	,224*	,188*	,246**	-,035	-,002	,267	,113	-,145	,046	,043	,071
T1M10	,034	,138	,168	,060	,057	,521**	,340**	,071	,156	,278**	,452**	,329**	,428**
T1M11	-,010	,057	,149	,200*	,100	,431**	,338**	-,034	-,159	,232*	,251**	,213*	,237*
T1SPL	,148	,372**	,224	,254*	,121	,081	,113	,281	,450*	,046	,017	,157	,072
T1TPW	,386**	,278**	,427**	,393**	,425**	,353**	,148	,334	,154	,193	,437**	,319**	,430**

	L1M1	L1M6	L1M9	L1PHL	L1PHR	L1M10	L1M11	L1SPL	L1TPW	L1IFLCR	L1IFLCA	L1IFRCR	L1IFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
L1SPL	.362**	.186	.490**	.344**	.588**	.131	.127	1	.474*	-.159	.013	-.053	.126
L1TPW	.153	.247	-.063	-.046	.134	.181	.222	.224	1	-.007	-.056	.186	.222
L1IFLCR	.017	.034	-.011	-.154	-.161	.388**	.379**	.052	.187	1	.607**	.808**	.570**
L1IFLCA	.131	.008	-.107	-.013	-.070	.592**	.374**	.168	.271*	.536**	1	.484**	.751**
L1IFRCR	.086	.030	-.018	-.035	-.027	.350**	.258**	.166	.110	.761**	.522**	1	.546**
L1IFRCA	.184*	.145	-.058	-.007	-.072	.617**	.474**	.141	.208	.597**	.808**	.587**	1
L5M2	.504**	.388**	.227*	.354**	.354**	.079	.022	.217	-.003	-.039	.076	.074	.190*
L5M1	.580**	.392**	.396**	.303**	.210*	.308**	.133	.319*	.088	-.009	.061	-.026	.155
L5M6	.250**	.428**	.243**	.257**	.248**	-.010	.008	.083	.081	-.020	-.030	-.018	.054
L5M9	.347**	.458**	.507**	.347**	.303**	.083	.275**	.118	-.117	.175	.064	.099	.213*
L5PHL	.318**	.383**	.235*	.432**	.448**	.112	.081	.353*	.086	-.116	.035	-.041	.118
L5PHR	.246**	.341**	.289**	.343**	.344**	.157	.052	.380**	.236	-.058	.013	-.052	.068
L5M10	.033	-.083	.075	.106	-.023	.391**	.366**	.227	.264	.150	.248*	-.016	.322**
L5M11	.119	.201*	.252**	.188*	.109	.427**	.552**	.298*	.284*	.385**	.396**	.265**	.467**
L5SPL	.192	.343*	.301*	.057	.200	.022	-.045	.483**	.219	-.162	-.014	.022	.004
L5TPW	.068	.087	-.021	-.078	-.063	.070	.091	.098	.108	.112	.230	.113	.226
L5IFLCR	.053	.058	.070	.101	.079	.380**	.300**	.386**	.066	.401**	.474**	.417**	.500**
L5IFLCA	.069	-.079	.055	-.033	.007	.321**	.354**	.267	-.001	.278**	.351**	.218*	.374**
L5IFRCR	.073	.012	.041	.128	-.054	.421**	.280**	.316*	-.089	.443**	.534**	.322**	.471**
L5IFRCA	.187*	-.017	.191*	.059	.056	.345**	.397**	.228	.172	.334**	.328**	.300**	.352**
FMM16	-.104	.156	.088	.057	.028	.245	.231	-.088	.184	.254	.303	.065	.150
FMM7	-.111	.057	-.005	-.133	-.274	.459**	.330*	.088	.186	.362*	.506**	.179	.377*
HLM1	.363**	.334**	.478**	.257**	.250**	.298**	.308**	.200	.257	.225*	.138	.044	.179
HCM7	.404**	.303**	.470**	.248**	.346**	.124	.172*	.456**	.130	.042	-.083	.015	.017
FHBM18	.419**	.434**	.504**	.293**	.257**	.334**	.382**	.387**	.304*	.112	.172	-.026	.290**
FLM1	.475**	.276**	.356**	.264**	.222*	.255**	.239**	.124	.307*	.201*	.141	.014	.190*
FCM8	.279**	.305**	.379**	.191*	.233**	.249**	.257**	.466**	.274*	.062	.026	-.072	.083
BWM2	.067	.344**	.311**	.084	.228*	.229	.283*	.354*	.522**	.261*	.222	.185	.254*

	L1M1	L1M6	L1M9	L1PHL	L1PHR	L1M10	L1M11	L1SPL	L1TPW	L1IFLCR	L1IFLCA	L1IFRCR	L1IFRCA
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
T1IFLCR	-,089	-,075	-,228*	-,160	-,151	,360**	,181	-,035	-,074	,312**	,240*	,154	,269**
T1IFLCA	-,092	,016	,007	,042	,068	,382**	,126	-,015	,182	,292**	,351**	,278**	,385**
T1IFRCR	-,149	-,045	-,139	-,034	-,045	,270**	,029	,022	,053	,164	,237*	,166	,313**
T1IFRCA	,018	-,034	,066	-,002	,000	,404**	,125	-,021	,202	,224*	,348**	,289**	,409**
T6M2	,354**	,436**	,423**	,383**	,340**	,189*	,159	,272	,219	-,101	,084	,127	,107
T6M1	,146	,308**	,289**	,303**	,243**	,066	,086	,007	,002	-,117	-,015	,062	-,024
T6M6	,123	,582**	,522**	,306**	,182	,101	,198*	,389**	,432**	,038	,113	,088	,143
T6M9	,366**	,517**	,612**	,419**	,282**	,024	,091	,380**	,462**	-,168	-,085	,024	-,044
T6PHL	,194*	,350**	,412**	,410**	,379**	,138	,067	,214	,191	-,122	-,004	,163	-,005
T6PHR	,153	,328**	,398**	,474**	,427**	,083	,094	,213	,178	-,138	-,018	,086	-,034
T6M10	,043	,118	,225*	,190	,231*	,326**	,365**	,240	-,079	,158	,286**	,162	,137
T6M11	,052	,057	,276**	-,001	-,041	,370**	,621**	-,034	-,079	,205*	,169	,080	,103
T6SPL	,193	,023	,079	-,097	-,172	-,017	-,013	,100	-,148	-,159	-,170	-,017	,010
T6TPW	,140	,362**	,410**	,397**	,241*	,186	,195	,260	-,008	,106	,329**	,269*	,367**
T6IFLCA	-,079	,238*	,171	,205*	,169	,222*	,260*	-,012	-,064	,148	,138	,195	,120
T6IFRCA	-,097	,107	,201	,013	-,050	,132	,215*	,085	-,028	,101	,064	,125	,050
T10M2	,417**	,282**	,315**	,241**	,150	,305**	,285**	,234	,292*	,034	,123	,095	,099
T10M1	,306**	,205*	,201*	,230*	,245**	,181	,236*	,183	,179	,120	,095	,114	,107
T10M6	,160	,720**	,523**	,415**	,288**	,118	,271**	,302*	,356*	-,050	,053	,135	,203*
T10M9	,338**	,447**	,620**	,310**	,147	,145	,149	,403**	,369**	-,069	,014	,089	,005
T10PHL	,190*	,230*	,338**	,320**	,192*	,114	,097	,175	,238	-,216*	-,018	-,040	-,016
T10PHR	,271**	,233*	,360**	,315**	,196*	,129	,092	,190	,318*	-,105	,000	,020	,011
T10M10	,126	-,004	,152	,057	,102	,585**	,536**	,145	-,107	,368**	,353**	,307**	,275**
T10M11	,103	,022	,224*	,090	-,018	,372**	,695**	,126	,112	,366**	,290**	,194*	,148
T10SPL	,405**	,382**	,337*	,064	,124	,148	,280*	,627**	,376	,058	-,185	,106	-,026
T10TPW	,098	,251*	,073	,116	,219	,276*	,199	,222	,191	,409**	,312**	,443**	,394**
T10IFLCA	,088	-,050	-,006	,105	,062	,319**	,276**	,054	,059	,348**	,492**	,387**	,353**
T10IFRCA	,067	-,074	-,017	,039	,021	,317**	,158	,027	-,011	,245**	,382**	,218*	,281**
L1M2	,603**	,193*	,140	,392**	,429**	,201*	,021	,290*	,043	,063	,125	,188*	,108
L1M1	1	,014	,238**	,238**	,239**	,285**	,057	,519**	,146	,054	,187*	,119	,170
L1M6	,402**	1	,482**	,347**	,306**	-,177	,176*	,425**	,373**	-,133	-,088	-,009	,042
L1M9	,369**	,376**	1	,396**	,237**	,055	,257**	,347*	,314*	-,193*	,043	-,018	,033
L1PHL	,470**	,249**	,249**	1	,742**	-,017	,086	,177	,115	-,074	,145	,145	,123
L1PHR	,449**	,222*	,281**	,790**	1	-,030	,029	,210	,097	-,062	,088	,162	,111
L1M10	,129	-,072	,103	,103	-,021	1	,462**	-,010	,004	,535**	,603**	,423**	,564**
L1M11	,054	,035	,326**	,009	-,046	,584**	1	,081	,072	,374**	,391**	,226*	,254**

	L5M2	L5M1	L5M6	L5M9	L5PHL	L5PHR	L5M10	L5M11	L5SPL	L5TPW	L5IFLCR	L5IFLCA	L5IFRCR
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
C3M2	,393**	,365**	,503**	,419**	,269**	,280**	,014	,131	,379*	,405**	,032	-,091	-,088
C3M1	,271**	,433**	,378**	,373**	,349**	,386**	,034	,150	,296	,297	,049	-,078	,018
C3M6	,118	,072	,437**	,524**	,214*	,254*	,037	,107	,072	,023	-,005	-,035	-,143
C3M9	,141	,188	,235*	,430**	,053	,011	,106	,142	,310*	,156	,100	-,019	-,006
C3PHL	,344**	,188	,447**	,364**	,310**	,279**	,024	-,083	,128	,090	,002	-,207*	-,010
C3PHR	,298**	,198	,391**	,424**	,297**	,274**	,067	,019	,043	,176	,114	-,109	,079
C3M10	-,164	,152	,005	-,083	-,048	-,103	,346**	,300**	,376*	,421**	,241*	,389**	,295**
C3M11	,181	,274**	,359**	,413**	,054	-,002	,142	,377**	,212	,410**	,175	,116	,046
C3TPW	,320*	,226	,202	,389**	,027	-,012	,484**	,267*	,234	,304	,267*	,063	,216
C3IFLCR	-,121	-,090	-,059	-,032	-,220*	-,237*	,341**	,172	,094	,107	,315**	,299**	,244*
C3IFLCA	-,033	,059	,166	,089	-,066	-,005	,219*	,227*	-,078	,312	,197	,226*	,141
C3IFRCR	-,048	-,009	-,043	-,028	-,066	-,122	,147	,077	,222	,109	,267**	,312**	,229*
C3IFRCA	-,193	-,059	,042	,054	-,103	,056	,331**	,256*	,096	,373*	,299**	,248*	,302**
C7M2	,487**	,350**	,277**	,376**	,336**	,328**	-,010	,118	,240	,334*	,052	-,044	-,001
C7M1	,396**	,353**	,178	,394**	,308**	,304**	-,047	,135	,043	,367*	,079	-,040	,033
C7M6	,095	,183	,340**	,351**	,147	,162	,150	,271**	,299	,129	,083	,029	,086
C7M9	,085	,226*	,315**	,350**	,121	,154	,141	,289**	,139	,303*	-,028	-,092	-,017
C7PHL	,225*	,106	,222*	,187	,192*	,253**	,213*	,042	,153	,182	,028	-,080	,056
C7PHR	,191*	,163	,296**	,185	,213*	,257**	,187	-,041	,257	,278	,156	-,091	,086
C7M10	,058	,143	,073	,103	-,052	-,044	,161	,292**	,317*	,198	,362**	,373**	,344**
C7M11	,066	,093	,077	,130	,050	-,021	,142	,324**	,014	,254	,199*	,272**	,197*
C7SPL	,087	,108	,410**	,283*	,095	,218	-,022	,143	,375*	-,022	-,012	-,104	,011
C7IFLCR	-,115	-,017	-,084	-,175	-,238*	-,157	-,064	,057	-,147	,284	,229*	,335**	,174
C7IFLCA	,101	,062	,063	,107	-,115	-,014	-,007	,244*	-,048	,415**	,396**	,088	,275**
C7IFRCR	-,057	,137	-,098	-,144	-,138	-,100	,031	-,039	,044	,227	,222*	,283**	,159
C7IFRCA	,225*	,039	,040	,160	,029	-,033	,040	,239*	,092	,222	,397**	,231*	,362**
T1M2	,394**	,371**	,392**	,386**	,296**	,416**	-,003	,153	,045	,319*	-,028	-,086	-,080
T1M1	,431**	,303**	,297**	,271**	,396**	,464**	,006	,201*	,136	,452**	,001	,009	-,017
T1M6	,196*	,162	,368**	,405**	,185	,161	,000	,262**	,087	,159	,137	,038	-,022
T1M9	,253**	,168	,300**	,286**	,257**	,348**	,014	,191*	,178	,224	,037	-,065	,004
T1PHL	,246**	,134	,312**	,387**	,380**	,448**	-,033	,087	,106	,202	-,048	-,110	-,032
T1PHR	,233*	,008	,157	,286**	,366**	,428**	-,002	,100	-,043	,163	,029	,036	-,030
T1M10	,125	,198*	,109	,104	,061	,150	,145	,276**	,343*	,270	,425**	,270**	,373**
T1M11	,056	,155	,059	,177	-,021	-,120	,174	,291**	,325*	,161	,289**	,255**	,229*
T1SPL	,124	,351**	,402**	,360**	,268*	,260*	,166	,271*	,323	,245	-,131	-,143	-,079
T1TPW	,398**	,406**	,456**	,397**	,352**	,414**	,151	,278**	,258	,413**	,102	-,001	-,006

	L5M2	L5M1	L5M6	L5M9	L5PHL	L5PHR	L5M10	L5M11	L5SPL	L5TPW	L5IFLCR	L5IFLCA	L5IFRCR
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
T1IFLCR	-.003	-.061	-.195	-.131	-.228*	-.043	.148	.275**	.026	.236	.311**	.324**	.349**
T1IFLCA	.060	-.012	-.021	.110	-.004	.140	.074	.297**	.103	.196	.415**	.280**	.431**
T1IFRCR	.077	-.052	-.035	-.053	-.147	-.028	.065	.166	.249	-.245	.314**	.242*	.423**
T1IFRCA	-.015	-.005	-.026	.178	-.073	.116	.080	.414**	.183	.209	.398**	.342**	.408**
T6M2	.436**	.501**	.360**	.377**	.186	.292**	.151	.171	.129	.365*	.023	-.086	.007
T6M1	.305**	.447**	.126	.136	.117	.196*	.041	.013	.156	.226	.090	-.027	.119
T6M6	.218*	.270**	.522**	.421**	.204*	.319**	.027	.361**	-.015	.184	-.025	-.174	-.056
T6M9	.325**	.372**	.402**	.395**	.270**	.405**	-.076	.172	-.041	.306*	-.100	-.176	-.184
T6PHL	.387**	.225*	.368**	.302**	.323**	.323**	.068	.231*	.154	.306*	.085	-.112	-.007
T6PHR	.307**	.340**	.387**	.318**	.259**	.302**	.127	.148	.144	.346*	.010	-.164	-.028
T6M10	.048	.243*	.105	.304**	.074	-.088	.210*	.187	.388*	.319*	.162	.185	.147
T6M11	.045	.293**	.167	.294**	.083	.053	.123	.301**	.053	.310*	.053	.083	.049
T6SPL	.380*	.244	-.304	.044	.083	.315	-.108	-.153	.082	.052	-.092	-.004	.088
T6TPW	.285*	.295*	.406**	.367**	.338**	.265*	.030	.294*	.080	.336	.116	-.027	.079
T6IFLCA	-.055	.095	.071	.158	-.060	.075	.105	.167	.343*	.023	.336**	.128	.279**
T6IFRCA	-.132	-.015	-.035	.042	-.170	-.093	.044	.061	.154	.042	.326**	.065	.198
T10M2	.329**	.439**	.363**	.279**	.266**	.369**	.015	.285**	.180	.296*	-.060	-.033	-.066
T10M1	.262**	.398**	.209*	.201*	.121	.268**	.031	.152	.196	.138	-.056	-.009	-.012
T10M6	.239*	.365**	.415**	.332**	.148	.320**	.113	.135	.118	.303*	.026	-.067	-.128
T10M9	.210*	.294**	.436**	.446**	.274**	.319**	-.006	.392**	.156	.255	-.025	-.079	-.146
T10PHL	.235*	.417**	.235*	.257**	.361**	.341**	.059	.374**	.201	.128	-.066	.045	-.087
T10PHR	.128	.431**	.254**	.325**	.376**	.412**	.092	.346**	.311*	.372**	-.099	.055	-.095
T10M10	.005	.278**	.103	.287**	.144	.058	.185	.386**	.402**	.344*	.220*	.288**	.293**
T10M11	-.032	.218*	.034	.246**	-.054	-.096	.147	.399**	.222	.417**	.235*	.179	.198*
T10SPL	.257	.192	.320*	.385**	.064	-.043	.131	.087	.219	.023	-.112	-.033	-.170
T10TPW	.183	.166	.092	.090	.105	.035	.199	.147	.274	.174	.224	.135	.175
T10IFLCA	.187	.139	-.022	.056	-.104	.001	.108	.194*	.320*	.175	.470**	.219*	.429**
T10IFRCA	.086	.065	-.092	-.015	-.210*	-.156	.152	.272**	.271	.005	.398**	.265**	.353**
L1M2	.435**	.507**	.238**	.273**	.235**	.310**	.100	.168	.226	.346*	-.089	-.179*	-.061
L1M1	.393**	.440**	.228*	.243**	.218*	.275**	.086	.113	.284*	.352*	-.091	-.020	-.115
L1M6	.149	.281**	.394**	.293**	.068	.221*	.098	.128	-.073	.302*	-.058	-.152	-.200*
L1M9	.144	.323**	.400**	.483**	.234**	.285**	.023	.203*	.003	.372**	.064	-.148	-.112
L1PHL	.249**	.382**	.357**	.276**	.255**	.323**	.064	.063	.427**	.426**	.090	-.117	.032
L1PHR	.313**	.324**	.386**	.299**	.328**	.330**	.043	.017	.436**	.406**	.046	-.104	.027
L1M10	.142	.231*	.119	.218*	-.042	-.011	.371**	.329**	.230	.190	.224*	.371**	.270**
L1M11	.013	.240**	.124	.235**	.037	.059	.293**	.362**	.251	.417**	.198*	.217*	.115

	L5M2	L5M1	L5M6	L5M9	L5PHL	L5PHR	L5M10	L5M11	L5SPL	L5TPW	L5IFLCR	L5IFLCA	L5IFRCR
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
L1SPL	.232	.199	.320*	.276*	.046	.060	.190	.111	.436*	-.033	-.045	-.103	-.157
L1TPW	-.140	-.072	.378*	.095	.110	.282	-.032	.333*	-.103	-.070	-.145	-.072	-.083
L1IFLCR	-.057	.063	-.032	.025	-.075	-.007	.147	.254**	.041	.394**	.329**	.313**	.382**
L1IFLCA	.199*	.182	.003	.071	-.007	.034	.297**	.256**	.133	.313*	.367**	.354**	.420**
L1IFRCR	.214*	.026	.034	.043	.000	.176	.020	.082	.295*	.334*	.463**	.162	.385**
L1IFRCA	.109	.136	.027	.141	.007	.170	.285**	.294**	-.033	.178	.349**	.449**	.417**
L5M2	1	.390**	.185*	.126	.325**	.307**	-.172	-.128	.181	.044	.028	-.120	-.031
L5M1	.437**	1	.157	.219**	.291**	.301**	.156	.095	.409**	.416**	-.140	-.143	-.150
L5M6	.320**	.159	1	.459**	.246**	.287**	-.040	.106	.240	.013	-.040	-.284**	-.192*
L5M9	.352**	.141	.417**	1	.304**	.213*	.094	.290**	.063	.280*	.032	-.125	.026
L5PHL	.432**	.275**	.297**	.377**	1	.696**	-.054	.087	.240	.130	-.111	-.037	.004
L5PHR	.258**	.317**	.272**	.282**	.649**	1	-.003	.107	.191	.146	.027	-.041	.117
L5M10	-.022	.265**	-.074	.007	.032	.096	1	.341**	-.072	.176	.104	.329**	.191*
L5M11	-.052	.075	.087	.339**	.225*	.231**	.369**	1	-.127	.270*	.157	.339**	.224*
L5SPL	.323*	.136	.090	.105	.040	.126	-.161	-.287*	1	.005	.137	.048	.060
L5TPW	-.039	.203	-.026	.011	.085	-.027	.157	.198	.019	1	.201	.020	.065
L5IFLCR	.046	.139	-.084	.076	.033	-.075	.295**	.395**	-.091	.212	1	.362**	.740**
L5IFLCA	-.043	.123	-.149	-.050	.013	.053	.463**	.315**	-.149	.077	.421**	1	.418**
L5IFRCR	.017	.141	-.102	.079	.005	.021	.360**	.405**	-.204	.044	.697**	.470**	1
L5IFRCA	-.020	.204*	-.062	.064	-.024	-.060	.414**	.360**	-.058	.074	.471**	.747**	.529**
FMM16	.001	-.111	.212	.229	.117	.206	.156	.400**	-.131	.200	.217	.134	.276
FMM7	-.006	-.042	.084	.071	-.061	.163	.245	.374*	.064	-.103	.234	.205	.416**
HLM1	.439**	.394**	.313**	.352**	.167	.251**	.213*	.211*	.315*	-.093	.137	.146	.245*
HCM7	.323**	.300**	.184*	.300**	.184*	.209*	.106	.110	.286*	-.020	.010	.027	.008
FHBM18	.464**	.390**	.370**	.432**	.366**	.312**	.163	.333**	.419**	-.014	.180*	.145	.185*
FLM1	.401**	.359**	.261**	.277**	.263**	.200*	.103	.249*	.157	-.047	.056	.131	.117
FCM8	.331**	.253**	.228*	.201*	.189*	.221*	.165	.238**	.364**	-.091	.145	.119	.182*
FWM2	.016	.156	.069	.141	.137	.154	.101	.252*	.279	-.058	.156	.122	.041

	L5IFRCA	FMM16	FMM7	HLM1	HCM7	FHBM18	FLM1	FCM8	BiWM2
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
C3M2	-.141	.305*	.215	.300**	.437**	.480**	.291**	.362**	.357**
C3M1	-.100	.117	.281	.303**	.264**	.400**	.303**	.322**	.199
C3M6	-.219*	.217	.015	.082	.501**	.322**	.083	.367**	.051
C3M9	-.170	.347*	-.070	-.025	.341**	.233*	-.001	.299**	.058
C3PHL	-.197	.190	.064	.142	.523**	.338**	.117	.300**	.233
C3PHR	-.162	.183	.242	.180	.436**	.285**	.199	.278**	.000
C3M10	.299**	.245	.330*	.138	-.078	.067	.079	-.111	.226
C3M11	-.078	.327*	.361*	.469**	.280**	.300**	.303**	.301**	.454**
C3TPW	.044	.321	.001	.314*	.410**	.439**	.334**	.325**	-.003
C3IFLCR	.240*	-.038	-.005	.073	-.063	.044	-.088	-.031	.048
C3IFLCA	.088	-.019	-.072	.244*	.055	-.018	.042	.061	.286*
C3IFRCR	.220*	-.019	.050	.100	-.009	.005	.028	-.057	.214
C3IFRCA	.202	.161	.088	.211*	.067	-.068	-.006	-.036	.382**
C7M2	-.108	.204	.151	.239*	.289**	.280**	.156	.325**	.178
C7M1	-.056	.169	.079	.213*	.226*	.243**	.228*	.290**	-.089
C7M6	-.004	.244	.087	.238*	.340**	.437**	.231*	.313**	.224
C7M9	-.161	.118	-.014	.145	.279**	.348**	.145	.336**	.279*
C7PHL	-.074	.092	.192	.115	.185*	.201*	.139	.133	.164
C7PHR	-.040	-.061	-.090	.079	.180*	.255**	.053	.154	.056
C7M10	.184	.406**	.282*	.103	.075	.109	.106	.074	.288*
C7M11	.154	.204	.371**	.238*	.105	.287**	.187	.160	.247
C7SPL	-.086	.239	.096	.011	.342**	.219	.008	.155	.490**
C7IFLCR	.239*	.093	.226	.114	-.058	-.071	-.060	.034	.169
C7IFLCA	.025	.206	-.021	.186	.154	.053	.026	.093	.256
C7IFRCR	.151	.103	.378**	-.013	-.092	-.086	-.060	-.078	.299*
C7IFRCA	.177	.300*	-.013	.203*	.155	.109	.077	.057	.134
T1M2	-.192*	.173	.204	.248**	.289**	.350**	.320**	.358**	.226
T1M1	-.066	.169	.182	.276**	.210*	.382**	.290**	.281**	.197
T1M6	-.065	.372**	.088	.163	.359**	.415**	.133	.389**	.142
T1M9	-.050	.093	-.153	.186	.245**	.334**	.272**	.227*	.138
T1PHL	-.134	.132	-.037	.098	.261**	.264**	.080	.287**	-.024
T1PHR	-.074	.127	-.078	.126	.251**	.235**	.148	.275**	-.097
T1M10	.139	.223	.203	.207*	.185*	.150	.138	.094	.290*
T1M11	.125	.217	.262	.118	.078	.147	.013	.153	.167
T1SPL	-.235	.184	.164	.083	.376**	.358**	.246	.375**	.346*
T1TPW	-.037	.363*	.030	.469**	.368**	.548**	.486**	.433**	.120

	LSIFRCA	FMM16	FMM7	HLM1	HCM7	FHBM18	FLM1	FCM8	BIWM2
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
T1IFLCR	.248*	.348*	.272	.112	-.087	-.048	-.033	-.073	.151
T1IFLCA	.180	.231	.132	.100	.129	.029	-.059	.115	.226
T1IFRCR	.153	.349*	.124	-.002	.038	-.087	-.043	-.075	.136
T1IFRCA	.220*	.149	.146	.156	.090	.047	.048	.081	.287*
T6M2	-.031	.172	.105	.284**	.439**	.462**	.470**	.486**	.168
T6M1	.003	-.071	.082	.116	.214*	.306**	.307**	.351**	.103
T6M6	-.203*	.281	-.013	.309**	.457**	.531**	.337**	.399**	.159
T6M9	-.183	.110	.085	.292**	.408**	.491**	.210*	.534**	.267
T6PHL	-.135	.246	.104	.297**	.554**	.440**	.276**	.449**	.138
T6PHR	-.169	.384**	.214	.365**	.556**	.539**	.345**	.444**	.166
T6M10	.089	.033	.127	.129	.140	.182	.217*	.171	-.009
T6M11	-.023	.223	.458**	.140	-.014	.228*	.075	.112	.256
T6SPL	-.011	-.368	-.036	.092	-.122	.017	-.180	.004	-.021
T6TPW	-.123	.002	-.084	.359**	.442**	.394**	.480**	.369**	.094
T6IFLCA	.010	.018	.005	.090	.107	.246*	.032	.048	.297*
T6IFRCA	-.075	-.063	.165	-.025	.059	.083	-.047	.029	.337*
T10M2	-.075	.118	.270	.422**	.307**	.480**	.382**	.395**	.313*
T10M1	-.038	-.124	.208	.238*	.094	.305**	.175	.299**	.297*
T10M6	-.147	.251	.099	.341**	.511**	.486**	.360**	.466**	.294*
T10M9	-.155	.266	.180	.295**	.464**	.413**	.272**	.477**	.204
T10PHL	-.029	-.054	.119	.193*	.286**	.317**	.188	.321**	.114
T10PHR	-.051	-.030	.103	.232*	.363**	.291**	.154	.289**	.170
T10M10	.139	.323*	.328*	.273**	.201*	.214*	.207*	.162	.275*
T10M11	.077	.316*	.345*	.224*	.116	.106	.048	.115	.210
T10SPL	-.136	.207	.401	.310*	.524**	.320*	.122	.466**	.166
T10TPW	.063	.274	.014	.312**	.364**	.144	.235	.231*	.246
T10IFLCA	.171	.164	.090	.216*	.048	.161	.111	.039	.317*
T10IFRCA	.193	.003	-.151	.167	.065	.086	.072	.003	.091
L1M2	-.117	.217	.000	.362**	.289**	.322**	.370**	.429**	.323*
L1M1	.018	.074	-.109	.231*	.074	.214*	.184	.252**	.134
L1M6	-.179	.035	.072	.314**	.440**	.422**	.258**	.434**	.247
L1M9	-.138	.073	.027	.283**	.440**	.439**	.252**	.429**	.309*
L1PHL	-.028	.119	-.202	.148	.381**	.434**	.201*	.396**	.075
L1PHR	-.047	.038	-.199	.140	.334**	.407**	.134	.275**	.070
L1M10	.255**	.335*	.300*	.232*	.038	.216*	.237*	.183*	.300*
L1M11	.090	.243	.347*	.196*	.062	.199*	.119	.118	.324*

	L5IFRCA	FMM16	FMM7	HLM1	HCM7	FHBM18	FLM1	FCM8	BIWM2
	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation	Pearson Correlation
L1SPL	.022	.458	.051	.125	.392**	.409**	.043	.174	-.232
L1TPW	.094	-.041	-.096	.272	.221	.199	.101	.128	.175
L1IFLCR	.296**	.352*	.088	.290**	-.008	.095	.142	.074	.290*
L1IFLCA	.352**	.143	-.087	.223*	.020	.157	.198*	.085	.030
L1IFRCR	.195*	-.037	-.058	.110	.037	.119	.100	.092	.323*
L1IFRCA	.436**	.069	-.077	.219*	.039	.171	.182	.136	.106
L5M2	-.134	.136	-.035	.317**	.235**	.320**	.277**	.281**	.030
L5M1	-.177	.206	.017	.335**	.261**	.492**	.366**	.408**	.369**
L5M6	-.356**	.241	-.043	.343**	.417**	.528**	.433**	.390**	.372**
L5M9	-.172	.338*	.095	.373**	.502**	.401**	.279**	.405**	-.012
L5PHL	-.085	-.118	-.211	.263**	.253**	.317**	.215*	.233**	-.003
L5PHR	-.071	-.163	-.193	.266**	.204*	.350**	.247**	.300**	.199
L5M10	.380**	.132	.015	.025	.057	.202*	.127	.141	.006
L5M11	.248**	.337*	.136	.276**	.138	.221*	.290**	.239**	.152
L5SPL	-.097	-.190	-.146	.034	.211	.286*	-.021	.080	.453*
L5TPW	.075	.645**	.279	.326*	.219	.302*	.390**	.297*	.318
L5IFLCR	.328**	.063	-.067	-.033	.073	-.005	-.140	.050	.277*
L5IFLCA	.795**	.062	.153	-.016	-.150	-.160	-.180	-.077	.099
L5IFRCR	.443**	.181	-.047	.035	.029	-.001	-.011	.010	.130
L5IFRCA	*1*	.006	.000	-.077	-.231*	-.148	-.090	-.157	-.151
FMM16	*.242*	*1*	.477**	.243	.318*	.337*	.153	.246	.037
FMM7	*.227*	*.550**	*1*	.041	-.043	-.043	-.051	.128	.228
HLM1	*.232**	*.264*	*.110*	*1*	.524**	.592**	.813**	.561**	.442**
HCM7	*.132*	*-.216*	*-.179*	*.509**	*1*	.569**	.416**	.604**	.372**
FHBM18	*.259**	*.183*	*.249*	*.703**	*.453**	*1*	.561**	.624**	.372**
FLM1	*.211**	*.178*	*.178*	*.797**	*.341**	*.675**	*1*	.527**	.382**
FCM8	*.142*	*.053*	*.047*	*.593**	*.558**	*.548**	*.599**	*1*	.501**
BIWM2	*.115*	*.415**	*.248*	*.496**	*.190*	*.561**	*.405**	*.421**	*1*

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

10. Significant microevolutionary regressions

Variable (males)	Method	r	Significance
agegroup	Log	0.77	0.00
TH10 spinous process length	Log	0.48	0.00
TH6 left caudal intervertebral foramen width	Log	0.45	0.00
bi-iliac width	Qua	0.44	0.00
C3 spinal canal transverse diameter	Qua	0.43	0.00
TH10 vertebral body sagittal diameter	Log	0.42	0.00
C3 left cranial intervertebral foramen width	Qua	0.42	0.00
C3 right caudal intervertebral foramen width	Qua	0.40	0.00
C3 left caudal intervertebral foramen width	Qua	0.39	0.00
L5 transverse process width	Exp	0.39	0.00
TH6 sagittal diameter vertebral body	Exp	0.39	0.00
TH6 right caudal intervertebral foramen width	Pow	0.38	0.00
L1 spinal canal transverse diameter	Exp	0.37	0.00
L5 spinous processus length	Log	0.36	0.01
femoral head width	Exp	0.36	0.00
humerus length	Qua	0.36	0.00
TH10 transverse process width	Log	0.35	0.00
C3 spinal canal sagittal diameter	Pow	0.35	0.00
L1 left craniall intervertebral foramen width	Exp	0.34	0.00
C3 dorsal vertebral body height dorsal	Log	0.34	0.00
TH1 spinal canal sagittal diameter	Pow	0.33	0.00
C3 transverse process width	Pow	0.33	0.00
L1 right cranial intervertebral foramen width	Log	0.32	0.00
C3 ventral vertebral body height	Pow	0.31	0.00
L5 left cranial intervertebral foramen width	Log	0.31	0.00
TH10 left caudal intervertebral foramen width	Log	0.31	0.00
TH10 right caudal intervertebral foramen width	Log	0.30	0.00
C7 right pedicle height	Pow	0.30	0.00
C7 left cranial intervertebral foramen width	Exp	0.30	0.00
TH1 right caudal intervertebral foramen width	Qua	0.30	0.00
TH10 dorsal vertebral body height	Lin	0.29	0.00
L1 vertebral body transverse diameter	Qua	0.29	0.00
C7 transverse diameter spinal canal	Log	0.29	0.00
TH1 spinal canal transverse diameter	Pow	0.29	0.00
C3 right cranial intervertebral foramen width	Exp	0.28	0.00
L1 vertebral body sagittal diameter	Log	0.28	0.00
humerus circumference	Log	0.28	0.00
L1 left caudal intervertebral foramen width	Exp	0.28	0.00
C7 vertebral body sagittal diameter	Log	0.27	0.00
TH6 right pedicle height	Pow	0.27	0.00
L1 spinal canal sagittal diameter	Log	0.27	0.00
TH1 left caudal intervertebral foramen width	Log	0.27	0.00
C7 dorsal vertebral body height	Log	0.26	0.00
C7 right caudal intervertebral foramen width	Pow	0.25	0.00
TH10 right pedicle height	Pow	0.25	0.00
C7 left pedicle height	Pow	0.25	0.01
C7 left caudal intervertebral foramen width	Log	0.25	0.01
L5 spinal canal sagittal diameter	Log	0.24	0.01
TH6 transverse diameter vertebral body	Exp	0.24	0.01
femur length	Lin	0.23	0.01
femur circumference	Lin	0.20	0.01
C3 vertebral body transverse diameter	Qua	-0.33	0.00

Variable (females)	Method	r	Significance
bi-iliac width	Cub	0.55	0.00
C7 transverse diameter spinal canal	Cub	0.51	0.00
C3 right cranial intervertebral foramen width	Cub	0.49	0.00
TH1 spinal canal transverse diameter	Cub	0.47	0.00
L5 spinous processus length	Log	0.45	0.00
C3 spinal canal transverse diameter	Exp	0.43	0.00
femur circumference	Cub	0.43	0.00
femoral head width	Cub	0.42	0.00
L1 spinous process length	Log	0.39	0.00
TH10 transverse process width	Log	0.38	0.00
TH10 right caudal intervertebral foramen width	Qua	0.35	0.00
humerus length	Exp	0.35	0.00
L1 right cranial intervertebral foramen width	Cub	0.34	0.00
TH10 spinal canal sagittal diameter	Cub	0.33	0.00
L5 left caudal intervertebral foramen width	Log	0.33	0.00
TH10 vertebral body sagittal diameter	Log	0.32	0.00
TH6 sagittal diameter vertebral body	Exp	0.31	0.00
TH10 spinal canal transverse diameter	Exp	0.30	0.00
L5 right cranial intervertebral foramen width	Log	0.30	0.00
L1 spinal canal sagittal diameter	Log	0.30	0.00
C7 left caudal intervertebral foramen width	Lin	0.30	0.00
C7 right caudal intervertebral foramen width	Lin	0.29	0.00
TH1 transverse process width	Log	0.29	0.01
C3 spinal canal sagittal diameter	Log	0.29	0.00
C7 right cranial intervertebral foramen width	Log	0.28	0.00
L5 left cranial intervertebral foramen width	Log	0.27	0.00
L1 right caudal intervertebral foramina width	Log	0.26	0.00
TH10 vertebral body transverse diameter	Exp	0.26	0.00
TH1 right cranial intervertebral foramen width	Log	0.26	0.00
L5 right caudal intervertebral foramen width	Log	0.26	0.00
TH6 dorsal vertebral body height	Log	0.26	0.00
TH1 spinal canal sagittal diameter	Log	0.26	0.01
L5 spinal canal sagittal diameter	Pow	0.25	0.01
L1 left caudal intervertebral foramen width	Log	0.24	0.01
L1 spinal canal transverse diameter	Log	0.24	0.01
agegroup	Log	-0.15	0.04
L5 ventral vertebral body height	Pow	-0.26	0.00
L5 vertebral body transverse diameter	Qua	-0.28	0.00
TH6 right caudal intervertebral foramen width	Qua	-0.37	0.00
femur length	Cub	-0.39	0.00
C3 right caudal intervertebral foramen width	Qua	-0.44	0.00
C3 left caudal intervertebral foramen width	Qua	-0.45	0.00
TH10 left caudal intervertebral foramen width	Cub	-0.47	0.00
C3 left cranial intervertebral foramen width	Qua	-0.56	0.00

11. ANOVA of variables with major time groups (Non-Bonferroni tables: bold= significant; italic: decrease)

Males

	F	Sig.
AGEGROUP	5.42	.005
C3M2	6.93	.001
C3M1	4.13	.018
C3M6	1.01	.366
C3M9	8.33	.000
C3PHL	4.59	.012
C3PHR	3.13	.048
C3M10	5.32	.006
C3M11	7.54	.001
C3SPL	.14	.872
C3TPW	3.17	.048
C3IFLCR	4.47	.014
C3IFLCA	5.62	.005
C3IFRCR	1.82	.167
C3IFRCA	6.81	.002
C7M2	1.72	.184
C7M1	.91	.405
C7M6	7.25	.001
C7M9	.13	.876
C7PHL	1.98	.142
C7PHR	3.31	.040
C7M10	.95	.391
C7M11	8.17	.000
C7SPL	2.59	.082
C7TPW	1.93	.162
C7IFLCR	.96	.384
C7IFLCA	3.92	.022
C7IFRCR	1.63	.201
C7IFRCA	5.92	.004
T1M2	.35	.708
T1M1	.25	.780
T1M6	3.10	.049
T1M9	.60	.550
T1PHL	1.95	.147
T1PHR	.46	.631
T1M10	4.86	.009
T1M11	7.36	.001
T1SPL	2.03	.138
T1TPW	2.06	.133
T1IFLCR	1.68	.191
T1IFLCA	4.43	.014
T1IFRCR	1.11	.333
T1IFRCA	3.39	.037
T6M2	4.24	.017
T6M1	.01	.991
T6M6	10.39	.000
T6M9	1.58	.210
T6PHL	1.47	.234
T6PHR	3.85	.024
T6M10	3.30	.041
T6M11	1.35	.262
T6SPL	.48	.622
T6TPW	.28	.760
T6IFLCA	11.66	.000
T6IFRCA	8.15	.001
T10M2	11.47	.000
T10M1	2.79	.065
T10M6	11.22	.000
T10M9	1.92	.151
T10PHL	2.53	.084
T10PHR	2.62	.077
T10M10	3.44	.035
T10M11	4.14	.018
T10SPL	6.93	.002
T10TPW	4.17	.019
T10IFLCA	6.28	.003
T10IFRCA	7.35	.001
L1M2	.11	.897
L1M1	.71	.492
L1M6	5.15	.007
L1M9	4.87	.009
L1PHL	6.28	.002
L1PHR	3.40	.036
L1M10	4.27	.016
L1M11	7.07	.001
L1SPL	1.20	.308
L1TPW	.60	.554
L1IFLCR	3.90	.023
L1IFLCA	1.96	.145
L1IFRCR	4.28	.016
L1IFRCA	2.27	.108
L5M2	1.64	.197
L5M1	.67	.513
L5M6	3.40	.037
L5M9	.54	.586
L5PHL	.27	.766
L5PHR	.08	.927
L5M10	4.05	.020
L5M11	1.98	.143
L5SPL	7.65	.001
L5TPW	1.53	.226
L5IFLCR	7.16	.001
L5IFLCA	.48	.618
L5IFRCR	1.43	.243
L5IFRCA	.27	.764
FMM16	.805	.453
FMM7	3.675	.032
HLM1	15.182	.000
HCM7	8.693	.000
FHBM18	14.412	.000
FLM1	10.215	.000
FCM8	8.450	.002
BIWM2	4.501	.015

	F	Sig.
C3M6/M9	9.074	.000
C3M10/M11	.911	.406
C7M6/M9	6.157	.003
C7M10/M11	2.012	.138
T1M6/M9	1.784	.173
T1M10/M11	.436	.648
T6M6/M9	8.980	.000
T6M10/M11	.461	.632
T10M6/M9	5.783	.004
T10M10/M11	.155	.857
L1M6/M9	.693	.502
L1M10/M11	.086	.918
L5M6/M9	2.677	.073
L5M10/M11	4.360	.015
FMM7/M16	1.880	.164
HM7/M1	5.904	.004
FM8/M1	1.315	.272

Females

	F	Sig.
AGEGROUP	2,90	,058
C3M2	2,26	,109
C3M1	,65	,526
C3M6	,66	,518
C3M9	4,66	,011
C3PHL	1,64	,199
C3PHR	,73	,482
C3M10	2,69	,073
C3M11	11,60	,000
C3SPL	5,00	,011
C3TPW	3,56	,034
C3IFLCR	8,10	,001
C3IFLCA	7,72	,001
C3IFRCR	2,10	,127
C3IFRCA	3,89	,023
C7M2	1,68	,191
C7M1	,20	,820
C7M6	3,35	,038
C7M9	,83	,440
C7PHL	,87	,423
C7PHR	1,35	,263
C7M10	1,54	,218
C7M11	18,78	,000
C7SPL	1,75	,182
C7TPW	1,20	,315
C7IFLCR	1,57	,212
C7IFLCA	3,39	,037
C7IFRCR	2,94	,057
C7IFRCA	3,68	,028
T1M2	,93	,399
T1M1	,24	,785
T1M6	,80	,453
T1M9	,10	,906
T1PHL	,25	,782
T1PHR	,13	,874
T1M10	3,33	,039
T1M11	14,67	,000
T1SPL	2,27	,114
T1TPW	3,93	,023
T1IFLCR	1,45	,240
T1IFLCA	,55	,577
T1IFRCR	2,54	,083
T1IFRCA	1,06	,350
T6M2	4,76	,010
T6M1	1,09	,341
T6M6	7,27	,001
T6M9	,71	,493
T6PHL	,98	,380
T6PHR	1,87	,159
T6M10	1,55	,217
T6M11	,87	,420
T6SPL	,87	,428
T6TPW	,96	,388
T6IFLCA	1,26	,289
T6IFRCA	3,55	,033
T10M2	,61	,545
T10M1	1,84	,163
T10M6	6,23	,003
T10M9	1,71	,185
T10PHL	1,06	,350
T10PHR	1,41	,249
T10M10	5,78	,004
T10M11	4,28	,016
T10SPL	2,39	,101
T10TPW	7,09	,001
T10IFLCA	9,14	,000
T10IFRCA	8,76	,000
L1M2	1,55	,217
L1M1	,79	,454
L1M6	,85	,431
L1M9	,88	,417
L1PHL	,22	,802
L1PHR	,70	,496
L1M10	4,89	,009
L1M11	4,24	,016
L1SPL	4,92	,011
L1TPW	2,95	,061
L1IFLCR	1,58	,210
L1IFLCA	2,15	,121
L1IFRCR	6,32	,003
L1IFRCA	2,98	,055
L5M2	,07	,933
L5M1	2,85	,061
L5M6	,97	,381
L5M9	3,43	,035
L5PHL	,45	,636
L5PHR	,35	,703
L5M10	2,66	,074
L5M11	1,68	,190
L5SPL	4,62	,014
L5TPW	1,95	,150
L5IFLCR	5,87	,004
L5IFLCA	7,13	,001
L5IFRCR	6,05	,003
L5IFRCA	3,92	,022
FMM16	,054	,947
FMM7	3,033	,057
HLM1	5,666	,004
HCM7	2,931	,057
FHBM16	13,548	,000
FLM1	9,083	,000
FCM8	15,072	,000
BIWM2	11,624	,000

	F	Sig.
C3M6/M9	2,745	,068
C3M10/M11	,483	,618
C7M6/M9	4,581	,012
C7M10/M11	4,728	,011
T1M6/M9	,694	,502
T1M10/M11	4,544	,013
T6M6/M9	6,327	,002
T6M10/M11	,053	,948
T10M6/M9	1,356	,262
T10M10/M11	,999	,371
L1M6/M9	,636	,531
L1M10/M11	,724	,487
L5M6/M9	1,062	,349
L5M10/M11	1,044	,356
FMM7/M16	3,801	,036
HM7/M1	13,053	,000
FM8/M1	3,390	,037

Multiple Comparisons - males

Bonferroni

Dependent Variable	(I) Time group	(J) Time group	Mean Difference (I-J)	Sig.
AGEGROUP	1	2	-,30	,07
		3	-,50*	,00
	2	3	-,20	,34
C3M2	1	2	-,06	1,00
		3	-,87*	,01
	2	3	-,81*	,00
C3M1	1	2	-,38	,47
		3	-,81*	,02
	2	3	-,43	,18
C3M6	1	2	-,28	1,00
		3	-,55	,48
	2	3	-,27	1,00
C3M9	1	2	1,85*	,00
		3	1,16	,06
	2	3	-,69	,24
C3PHL	1	2	,55	,09
		3	-,02	1,00
	2	3	-,56*	,03
C3PHR	1	2	,21	1,00
		3	-,28	,83
	2	3	-,49*	,04
C3M10	1	2	-,60	,37
		3	-1,32*	,01
	2	3	-,72	,09
C3M11	1	2	-1,24*	,00
		3	-1,47*	,00
	2	3	-,23	1,00
C3SPL	1	2	-,63	1,00
		3	-,91	1,00
	2	3	-,28	1,00
C3TPW	1	2	-2,19	,24
		3	-3,36*	,04
	2	3	-1,16	,86
C3IFLCR	1	2	-,46	,26
		3	-,88*	,01
	2	3	-,41	,23
C3IFLCA	1	2	-,86*	,04
		3	-1,23*	,00
	2	3	-,37	,58
C3IFRCR	1	2	-,31	,60
		3	-,50	,18
	2	3	-,19	1,00
C3IFRCA	1	2	-,85*	,03
		3	-1,31*	,00
	2	3	-,45	,31
C7M2	1	2	-,32	,67
		3	-,53	,20
	2	3	-,21	1,00
C7M1	1	2	-,14	1,00
		3	,22	1,00
	2	3	,36	,54
C7M6	1	2	-1,01*	,01
		3	-1,47*	,00
	2	3	-,46	,40
C7M9	1	2	-,15	1,00
		3	-,32	1,00

Dependent Variable	(I) Time group	(J) Time group	Mean Difference (I-J)	Sig.
C7M9	2	3	-,17	1,00
C7PHL	1	2	-,06	1,00
		3	-,40	,33
	2	3	-,34	,22
C7PHR	1	2	,05	1,00
		3	-,40	,27
	2	3	-,46*	,04
C7M10	1	2	-,36	,91
		3	-,52	,52
	2	3	-,15	1,00
C7M11	1	2	-1,11	,08
		3	-2,14*	,00
	2	3	-1,03*	,04
C7SPL	1	2	,70	1,00
		3	-1,79	,59
	2	3	-2,48	,08
C7TPW	1	2	-14,90	,18
		3	-12,74	,47
	2	3	2,16	1,00
C7IFLCR	1	2	-,21	1,00
		3	-,35	,50
	2	3	-,14	1,00
C7IFLCA	1	2	-,79	,06
		3	-,96*	,02
	2	3	-,17	1,00
C7IFRCR	1	2	-,03	1,00
		3	-,31	,46
	2	3	-,27	,30
C7IFRCA	1	2	-,89*	,02
		3	-1,14*	,00
	2	3	-,25	1,00
T1M2	1	2	-,23	1,00
		3	-,27	1,00
	2	3	-,05	1,00
T1M1	1	2	-,23	1,00
		3	-,15	1,00
	2	3	,08	1,00
T1M6	1	2	-,63	,31
		3	-1,07*	,04
	2	3	-,44	,56
T1M9	1	2	,36	1,00
		3	-,25	1,00
	2	3	-,61	,86
T1PHL	1	2	,56	,19
		3	,56	,25
	2	3	,00	1,00
T1PHR	1	2	-,05	1,00
		3	,18	1,00
	2	3	,23	1,00
T1M10	1	2	-,60	,10
		3	-,94*	,01
	2	3	-,34	,46
T1M11	1	2	-,85	,19
		3	-1,83*	,00
	2	3	-,97*	,04

Dependent Variable	(I) Time group	(J) Time group	Mean Difference (I-J)	Sig.
T1SPL	1	2	-,43	1,00
		3	-2,41	,22
	2	3	-1,98	,26
T1TPW	1	2	-3,08	,26
		3	-3,75	,15
	2	3	-,67	1,00
T1IFLCR	1	2	-,36	,47
		3	-,50	,21
	2	3	-,14	1,00
T1IFLCA	1	2	-,19	1,00
		3	-,97*	,04
	2	3	-,78*	,03
T1IFRCR	1	2	-,05	1,00
		3	-,31	,67
	2	3	-,26	,55
T1IFRCA	1	2	-,48	,46
		3	-,91*	,03
	2	3	-,43	,35
T6M2	1	2	-1,04*	,01
		3	-,86	,10
	2	3	,18	1,00
T6M1	1	2	-,01	1,00
		3	,03	1,00
	2	3	,04	1,00
T6M6	1	2	-2,20*	,00
		3	-2,47*	,00
	2	3	-,27	1,00
T6M9	1	2	-,90	,23
		3	-,69	,65
	2	3	,21	1,00
T6PHL	1	2	-,40	,51
		3	-,53	,29
	2	3	-,13	1,00
T6PHR	1	2	-,57	,18
		3	-,90*	,02
	2	3	-,33	,60
T6M10	1	2	-,17	1,00
		3	-,72	,07
	2	3	-,55	,11
T6M11	1	2	-,06	1,00
		3	-,53	,54
	2	3	-,47	,42
T6SPL	1	2	1,55	1,00
		3	2,23	1,00
	2	3	,69	1,00
T6TPW	1	2	-1,08	1,00
		3	-1,33	1,00
	2	3	-,25	1,00
T6IFLCA	1	2	-,45	1,00
		3	-2,14*	,00
	2	3	-1,69*	,00
T6IFRCA	1	2	-,09	1,00
		3	-1,40*	,01
	2	3	-1,31*	,00
T10M2	1	2	-1,64*	,00
		3	-1,37*	,00
T10M2	2	3	,27	1,00
T10M1	1	2	-,81	,06
		3	-,60	,38
	2	3	,21	1,00
T10M6	1	2	-2,50*	,00
		3	-3,46*	,00
	2	3	-,96	,33
T10M9	1	2	-1,19	,29
		3	-1,46	,19
	2	3	-,27	1,00
T10PHL	1	2	-,62	,20
		3	-,79	,09
	2	3	-,17	1,00
T10PHR	1	2	-,25	1,00
		3	-,72	,10
	2	3	-,47	,23
T10M10	1	2	-,69	,11
		3	-,90*	,04
	2	3	-,21	1,00
T10M11	1	2	-1,04*	,03
		3	-1,10*	,03
	2	3	-,05	1,00
T10SPL	1	2	-2,11	,33
		3	-5,93*	,00
	2	3	-3,82*	,05
T10TPW	1	2	-2,42	,38
		3	-4,90*	,02
	2	3	-2,48	,24
T10IFLCA	1	2	-,88	,12
		3	-1,63*	,00
	2	3	-,75	,14
T10IFRCA	1	2	-,63	,42
		3	-1,71*	,00
	2	3	-1,08*	,02
L1M2	1	2	-,09	1,00
		3	,06	1,00
	2	3	,14	1,00
L1M1	1	2	-,13	1,00
		3	,36	1,00
	2	3	,49	,71
L1M6	1	2	-1,09	,27
		3	-2,35*	,01
	2	3	-1,26	,11
L1M9	1	2	-1,76*	,03
		3	-2,26*	,01
	2	3	-,51	1,00
L1PHL	1	2	,09	1,00
		3	-,83*	,04
	2	3	-,92*	,00
L1PHR	1	2	,37	,83
		3	-,32	1,00
	2	3	-,70*	,04
L1M10	1	2	-,76	,08
		3	-1,09*	,01
	2	3	-,33	,85

Dependent Variable	(I) Time group	(J) Time group	Mean Difference (I-J)	Sig.
L1M11	1	2	-1,10*	,01
		3	-1,57*	,00
	2	3	-,47	,52
L1SPL	1	2	-,30	1,00
		3	-2,69	,43
	2	3	-2,39	,51
L1TPW	1	2	-2,17	1,00
		3	-4,57	,88
	2	3	-2,40	1,00
L1IFLCR	1	2	-,47	,21
		3	-,82*	,02
	2	3	-,35	,44
L1IFLCA	1	2	-,52	,56
		3	-,88	,15
	2	3	-,36	,99
L1IFRCR	1	2	-,05	1,00
		3	-,67	,05
	2	3	-,62*	,02
L1IFRCA	1	2	-,55	,44
		3	-,91	,11
	2	3	-,36	,92
L5M2	1	2	-,51	,79
		3	,18	1,00
	2	3	,70	,28
L5M1	1	2	-,43	1,00
		3	-,69	,75
	2	3	-,26	1,00
L5M6	1	2	-1,25	,18
		3	-1,96*	,03
	2	3	-,72	,82
L5M9	1	2	-,98	,91
		3	-,65	1,00
	2	3	,32	1,00
L5PHL	1	2	,00	1,00
		3	,25	1,00
	2	3	,25	1,00
L5PHR	1	2	-,01	1,00
		3	,14	1,00
	2	3	,15	1,00
L5M10	1	2	-,51	,89
		3	-1,47*	,02
	2	3	-,96	,11
L5M11	1	2	-1,12	,15
		3	-,86	,50
	2	3	,25	1,00
L5SPL	1	2	1,94	,35
		3	-3,21	,12
	2	3	-5,14*	,00
L5TPW	1	2	-,44	1,00
		3	-8,14	,52
	2	3	-7,70	,34
L5IFLCR	1	2	-,04	1,00
		3	-,70*	,01
	2	3	-,66*	,00
L5IFLCA	1	2	-,35	1,00
		3	-,46	1,00
L5IFLCA	2	3	-,11	1,00
L5IFRCR	1	2	-,07	1,00
		3	-,36	,43
	2	3	-,29	,42
L5IFRCA	1	2	-,29	1,00
		3	-,19	1,00
	2	3	,11	1,00
FMM16	1	2	-1,08	,86
		3	-1,15	,67
	2	3	-,07	1,00
FMM7	1	2	-2,25	,08
		3	-2,45*	,03
	2	3	-,20	1,00

Dependent Variable	(I) Time group	(J) Time group	Mean Difference (I-J)	Sig.
HLM1	1	2	-21,13*	,00
		3	-12,38*	,01
	3	2	-8,76*	,03
HCM7	1	2	-3,12*	,00
		3	-4,46*	,00
	3	2	1,35	,39
FHBM18	1	2	-2,95*	,00
		3	-3,35*	,00
	3	2	,39	1,00
FLM1	1	2	-26,55*	,00
		3	-15,60	,06
	3	2	-10,95	,12
FCM8	1	2	-4,70*	,00
		3	-3,23	,10
	3	2	-1,47	,72
BIWM2	1	2	-9,23	,31
		3	-16,88*	,01
	3	2	-7,64	,29

*. The mean difference is significant at the ,05 level.

Multiple Comparisons - females

Bonferroni

Dependent Variable	(I) Time group	(J) Time group	Mean Difference (I-J)	Sig.
AGEGROUP	1	2	-,25	,14
		3	-,34	,11
	3	2	,09	1,00
C3M2	1	2	-,26	,75
		3	-,59	,11
	3	2	,33	,59
C3M1	1	2	-,11	1,00
		3	-,37	,78
	3	2	,26	1,00
C3M6	1	2	,30	,79
		3	,26	1,00
	3	2	,04	1,00
C3M9	1	2	1,26*	,02
		3	1,29	,06
	3	2	-,03	1,00
C3PHL	1	2	,29	,39
		3	,00	1,00
	3	2	,29	,47
C3PHR	1	2	,06	1,00
		3	-,16	1,00
	3	2	,23	,68
C3M10	1	2	-,19	1,00
		3	-,79	,09
	3	2	,59	,19
C3M11	1	2	-1,04*	,00
		3	-1,58*	,00
	3	2	,54	,28
C3SPL	1	2	-,12	1,00
		3	-3,03*	,02
	3	2	2,92*	,02
C3TPW	1	2	-1,02	1,00
		3	-3,17*	,04
	3	2	2,15	,13
C3IFLCR	1	2	-,91*	,00
		3	-,94*	,01
	3	2	,02	1,00
C3IFLCA	1	2	-1,18*	,00
		3	-1,25*	,01
	3	2	,06	1,00
C3IFRCR	1	2	-,45	,24
		3	-,57	,22
	3	2	,12	1,00
C3IFRCA	1	2	-,84*	,03
		3	-,79	,13
	3	2	-,06	1,00
C7M2	1	2	-,43	,21
		3	-,31	,87
	3	2	-,12	1,00
C7M1	1	2	,08	1,00
		3	,19	1,00
	3	2	-,11	1,00
C7M6	1	2	-,58	,14
		3	-,88*	,05
	3	2	,30	1,00
C7M9	1	2	,21	1,00
		3	,69	,62

Dependent Variable	(I) Time group	(J) Time group	Mean Difference (I-J)	Sig.
C7M9	3	2	-,48	,98
C7PHL	1	2	-,21	,91
		3	,03	1,00
	3	2	-,24	,82
C7PHR	1	2	-,31	,33
		3	-,26	,76
	3	2	-,04	1,00
C7M10	1	2	-,45	,35
		3	-,51	,42
	3	2	,06	1,00
C7M11	1	2	-1,47*	,00
		3	-2,64*	,00
	3	2	1,17*	,01
C7SPL	1	2	1,73	,20
		3	1,21	,90
	3	2	,52	1,00
C7TPW	1	2	-10,62	,41
		3	-4,64	1,00
	3	2	-5,98	1,00
C7IFLCR	1	2	-,12	1,00
		3	-,41	,25
	3	2	,29	,54
C7IFLCA	1	2	-,58	,13
		3	-,83*	,05
	3	2	,25	1,00
C7IFRCR	1	2	-,17	1,00
		3	-,53	,05
	3	2	,36	,22
C7IFRCA	1	2	-,59	,09
		3	-,82*	,04
	3	2	,24	1,00
T1M2	1	2	-,35	,62
		3	-,38	,76
	3	2	,03	1,00
T1M1	1	2	,12	1,00
		3	,22	1,00
	3	2	-,10	1,00
T1M6	1	2	-,30	1,00
		3	-,47	,65
	3	2	,17	1,00
T1M9	1	2	,08	1,00
		3	,27	1,00
	3	2	-,19	1,00
T1PHL	1	2	-,17	1,00
		3	-,07	1,00
	3	2	-,10	1,00
T1PHR	1	2	-,03	1,00
		3	,09	1,00
	3	2	-,12	1,00
T1M10	1	2	-,39	,47
		3	-,82*	,03
	3	2	,43	,38
T1M11	1	2	-1,61*	,00
		3	-2,30*	,00
	3	2	,69	,19

Dependent Variable	(I) Time group	(J) Time group	Mean Difference (I-J)	Sig.
T1SPL	1	2	,83	1,00
		3	-1,61	,63
	3	2	2,44	,11
T1TPW	1	2	-2,80	,13
		3	-4,25*	,02
	3	2	1,45	,69
T1IFLCR	1	2	-,09	1,00
		3	-,36	,35
	3	2	,27	,48
T1IFLCA	1	2	-,31	1,00
		3	-,38	1,00
	3	2	,07	1,00
T1IFRCR	1	2	-,02	1,00
		3	-,45	,21
	3	2	,43	,11
T1IFRCA	1	2	-,24	1,00
		3	-,57	,45
	3	2	,33	,98
T6M2	1	2	-,24	1,00
		3	-1,03*	,01
	3	2	,79*	,03
T6M1	1	2	,32	,72
		3	-,01	1,00
	3	2	,33	,70
T6M6	1	2	-1,55*	,00
		3	-1,96*	,00
	3	2	,40	1,00
T6M9	1	2	-,40	,92
		3	-,05	1,00
	3	2	-,35	1,00
T6PHL	1	2	,21	1,00
		3	-,07	1,00
	3	2	,28	,63
T6PHR	1	2	-,17	1,00
		3	-,48	,18
	3	2	,31	,46
T6M10	1	2	-,24	1,00
		3	-,53	,25
	3	2	,29	,81
T6M11	1	2	-,13	1,00
		3	-,53	,64
	3	2	,40	,83
T6SPL	1	2	1,95	,87
		3	-,25	1,00
	3	2	2,20	,79
T6TPW	1	2	-,90	1,00
		3	-2,16	,52
	3	2	1,26	1,00
T6IFLCA	1	2	-,52	,69
		3	-,78	,38
	3	2	,25	1,00
T6IFRCA	1	2	-1,03*	,03
		3	-,44	1,00
	3	2	-,60	,41
T10M2	1	2	,02	1,00
		3	-,37	1,00
T10M2	3	2	,38	,88
T10M1	1	2	-,11	1,00
		3	-,74	,24
	3	2	,63	,28
T10M6	1	2	-1,05	,06
		3	-1,93*	,00
	3	2	,88	,25
T10M9	1	2	-,63	,58
		3	-1,06	,22
	3	2	,43	1,00
T10PHL	1	2	-,03	1,00
		3	-,45	,60
	3	2	,41	,56
T10PHR	1	2	,21	1,00
		3	-,30	1,00
	3	2	,51	,30
T10M10	1	2	-,33	,77
		3	-1,17*	,00
	3	2	,83*	,03
T10M11	1	2	-,64	,12
		3	-1,06*	,02
	3	2	,41	,66
T10SPL	1	2	-,35	1,00
		3	-2,75	,13
	3	2	2,40	,22
T10TPW	1	2	-2,30	,22
		3	-5,51*	,00
	3	2	3,20	,06
T10IFLCA	1	2	-1,20*	,00
		3	-1,28*	,00
	3	2	,08	1,00
T10IFRCA	1	2	-,94*	,01
		3	-1,47*	,00
	3	2	,53	,37
L1M2	1	2	,62	,27
		3	,24	1,00
	3	2	,38	1,00
L1M1	1	2	,41	,80
		3	,02	1,00
	3	2	,39	1,00
L1M6	1	2	-,08	1,00
		3	-,72	,69
	3	2	,64	,73
L1M9	1	2	-,68	,76
		3	-,84	,74
	3	2	,17	1,00
L1PHL	1	2	,16	1,00
		3	,05	1,00
	3	2	,11	1,00
L1PHR	1	2	,31	,81
		3	,07	1,00
	3	2	,24	1,00
L1M10	1	2	-,40	,52
		3	-1,09*	,01
	3	2	,69	,11

Dependent Variable	(I) Time group	(J) Time group	Mean Difference (I-J)	Sig.
L1M11	1	2	-.63	.18
		3	-1.19*	.01
	3	2	.56	.44
L1SPL	1	2	.60	1.00
		3	-3.31*	.04
	3	2	3.91*	.01
L1TPW	1	2	-2.03	1.00
		3	-6.24	.06
	3	2	4.21	.29
L1IFLCR	1	2	-.11	1.00
		3	-.52	.28
	3	2	.41	.44
L1IFLCA	1	2	-.14	1.00
		3	-.72	.15
	3	2	.58	.28
L1IFRCR	1	2	.56	.11
		3	-.38	.68
	3	2	.93*	.00
L1IFRCA	1	2	-.28	.96
		3	-.82	.05
	3	2	.54	.27
L5M2	1	2	.06	1.00
		3	-.12	1.00
	3	2	.17	1.00
L5M1	1	2	-.19	1.00
		3	-1.45	.07
	3	2	1.27	.12
L5M6	1	2	.08	1.00
		3	.91	.58
	3	2	-.83	.63
L5M9	1	2	.54	1.00
		3	2.20*	.03
	3	2	-1.66	.12
L5PHL	1	2	.30	1.00
		3	.42	1.00
	3	2	-.12	1.00
L5PHR	1	2	.00	1.00
		3	.33	1.00
	3	2	-.33	1.00
L5M10	1	2	-.54	.75
		3	-1.31	.07
	3	2	.77	.42
L5M11	1	2	-.78	.46
		3	-1.14	.27
	3	2	.36	1.00
L5SPL	1	2	-1.30	.68
		3	-3.84*	.01
	3	2	2.54	.14
L5TPW	1	2	-1.85	1.00
		3	-9.35	.18
	3	2	7.49	.34
L5IFLCR	1	2	-.11	1.00
		3	-.79*	.01
	3	2	.68*	.01
L5IFLCA	1	2	-.86*	.05
		3	-1.56*	.00
L5IFLCA	3	2	.71	.22
L5IFRCR	1	2	-.21	.98
		3	-.88*	.00
	3	2	.67*	.02
L5IFRCA	1	2	-.37	.92
		3	-1.20*	.02
	3	2	.83	.13
FMM16	1	2	-.35	1.00
		3	-.29	1.00
	3	2	-.06	1.00
FMM7	1	2	.19	1.00
		3	-1.69	.21
	3	2	1.87	.09

Dependent Variable	(I) Time group	(J) Time group	Mean Difference (I-J)	Sig.
HLM1	1	2	-12.44*	.01
		3	-12.83*	.02
	3	2	.39	1.00
HCM7	1	2	.89	.76
		3	-1.20	.65
	3	2	2.09	.05
FHBM18	1	2	-1.96*	.00
		3	-2.56*	.00
	3	2	.59	.82
FLM1	1	2	-20.57*	.00
		3	-17.49*	.02
	3	2	-3.09	1.00
FCM8	1	2	-4.44*	.00
		3	-6.50*	.00
	3	2	2.06	.25
BIWM2	1	2	-11.84*	.02
		3	-22.21*	.00
	3	2	10.37*	.04

*. The mean difference is significant at the .05 level.

12. Alterations of standard deviation of variables with time group 1 *versus* 3 (F-values)

Variable (SD) - males	F (Time group 1 *versus* 3)	SD - Time group 1	SD - Time group 3
agegroup	1.40	0.7	0.8
C3M2	**2.32** *	0.9	1.4
C3M1	1.08	1.0	1.0
C3M6	1.58	1.9	1.5
C3M9	1.17	2.0	1.8
C3PHl	1.00	1.1	1.1
C3PHr	1.05	1.0	1.0
C3M10	1.10	1.5	1.5
C3M11	1.63	1.3	1.7
C3SPL	1.90	4.1	3.0
C3TPW	1.23	4.2	3.8
C3IFlcr	*3.17* **	1.5	0.9
C3IFlca	1.33	1.5	1.3
C3IFrcr	1.25	1.1	0.9
C3IFrca	1.15	1.4	1.3
C7M2	**2.01** *	0.9	1.3
C7M1	**2.87** **	0.9	1.5
C7M6	**2.33** *	1.1	1.7
C7M9	1.42	2.7	2.2
C7PHl	1.10	1.0	0.9
C7PHr	1.02	1.0	1.0
C7M10	1.10	1.5	1.5
C7M11	1.06	1.8	1.7
C7SPL	1.22	3.9	4.3
C7TPW	3.51	9.8	18.4
C7IFlcr	1.25	1.0	0.9
C7IFlca	1.34	1.3	1.5
C7IFrcr	1.73	1.0	0.7
C7IFrca	1.53	1.5	1.2
T1M2	1.34	1.2	1.4
T1M1	1.37	1.1	1.3
T1M6	**2.12** *	1.4	2.0
T1M9	1.35	2.4	2.8
T1PHl	1.10	1.2	1.3
T1TPHr	1.18	1.2	1.3
T1M10	1.02	1.3	1.2
T1M11	1.15	1.9	1.8
T1SPL	1.44	4.3	3.6
T1TPW	1.52	6.3	5.1
T1IFlcr	1.40	1.2	1.0
T1IFlca	1.00	1.5	1.5
T1IFrcr	1.14	1.0	1.0
T1IFrca	1.10	1.4	1.5
T6M2	1.24	1.5	1.4
T6M1	1.77	1.3	1.7
T6M6	**2.46** *	1.6	2.4
T6M9	1.65	1.8	2.3
T6PHl	1.45	1.5	1.1
T6PHr	*1.94* *	1.5	1.0
T6M10	1.18	1.2	1.3
T6M11	1.42	1.6	1.5
T6SPL	1.27	6.1	5.4
T6TPW	1.55	5.6	4.5
T6IFlca	1.72	1.3	1.8
T6IFrca	1.49	1.6	1.3

T10M2	1.26	1.3	1.5
T10M1	**2.03 ***	1.1	1.5
T10M6	**2.44 ***	2.1	3.3
T10M9	**2.02 ***	2.4	3.4
T10PHl	1.35	1.7	1.4
T10PHr	1.41	1.5	1.2
T10M10	**2.03 ***	1.1	1.6
T10M11	1.63	1.4	1.8
T10SPL	1.42	3.1	3.7
T10TPW	1.00	4.9	4.9
T10IFlca	1.18	2.0	1.8
T10IFrca	1.00	2.0	2.0
L1M2	1.44	1.3	1.6
L1M1	1.32	1.9	2.2
L1M6	1.10	3.0	2.9
L1M9	**2.60 ****	2.1	3.4
L1PHl	1.11	1.3	1.3
L1PHr	2.28 *	1.1	1.6
L1M10	1.50	1.5	1.7
L1M11	1.62	1.6	2.0
L1SPL	**4.66 ****	2.8	6.1
L1TPW	**9.12 ****	3.8	11.5
L1IFlcr	1.18	1.2	1.3
L1IFlca	**2.93 ****	1.4	2.3
L1IFrcr	**2.31 ***	0.9	1.3
L1IFrca	**2.39 ***	1.3	2.0
L5M2	1.17	2.1	1.9
L5M1	1.18	2.1	2.3
L5M6	1.61	2.4	3.1
L5M9	**2.23 ***	3.4	5.1
L5PHl	1.20	1.8	1.6
L5PHr	1.10	1.9	1.9
L5M10	1.60	1.8	2.3
L5M11	**2.21 ***	2.0	3.0
L5SPL	1.48	3.2	3.9
L5TPW	*5.09 **	17.2	7.6
L5IFlcr	1.04	1.0	1.0
L5IFlca	**2.17 ***	1.5	2.3
L5IFrcr	1.16	0.9	1.0
L5IFrca	1.02	1.7	1.7
FMM16	1.01	2.6	2.6
FMM7	1.55	1.8	2.3
HLM1	1.41	14.1	14.5
HCM7	1.26	4.4	5.6
FHM18	1.18	2.8	3.2
FLM1	1.05	20.9	25.3
FCM8	1.23	5.8	6.9
BIWM2	1.20	10.8	16.6

bold:	increase (significants only)
italic:	decrease (significants only)
*:	significant before ($p<0.05$) /
**:	after Bonferroni's correction

Variable (SD) - females	F (Time group 1 *versus* 3)	SD - time group 1	SD - time group 3
agegroup	**1.74** **	0.63	0.83
C3M2	2.19 *	0.91	1.35
C3M1	1.15	1.13	1.21
C3M6	1.12	1.33	1.41
C3M9	1.02	2.34	2.37
C3PHl	0.99	0.94	0.93
C3PHr	1.58	0.78	0.98
C3M10	2.07 *	1.03	1.48
C3M11	1.81	1.18	1.58
C3SPL	2.92 *	2.37	4.05
C3TPW	2.58 *	2.44	3.91
C3IFlcr	1.45	1.31	1.08
C3IFlca	1.65	1.61	1.25
C3IFrcr	-2.08 *	1.51	1.05
C3IFrca	1.67	1.71	1.32
C7M2	2.10 *	0.97	1.41
C7M1	1.87 *	1.02	1.40
C7M6	1.58	1.19	1.50
C7M9	1.30	2.12	1.86
C7PHl	1.20	0.88	0.97
C7PHr	1.40	0.92	1.08
C7M10	1.79	1.00	1.34
C7M11	1.43	1.49	1.78
C7SPL	2.10	4.14	2.86
C7TPW	2.22	14.64	21.79
C7IFlcr	1.07	0.82	0.85
C7IFlca	1.23	1.18	1.31
C7IFrcr	1.03	0.83	0.84
C7IFrca	1.11	1.11	1.17
T1M2	1.31	1.21	1.38
T1M1	1.38	1.19	1.40
T1M6	1.46	1.32	1.60
T1M9	1.06	2.00	2.06
T1PHl	1.41	1.07	1.27
T1TPHr	1.16	1.16	1.08
T1M10	1.65	0.92	1.18
T1M11	1.57	1.34	1.68
T1SPL	1.04	3.08	3.02
T1TPW	1.81	5.24	3.90
T1IFlcr	1.97 *	0.72	1.01
T1IFlca	1.21	1.22	1.34
T1IFrcr	1.13	0.98	0.92
T1IFrca	1.34	1.33	1.54
T6M2	1.09	1.34	1.40
T6M1	1.11	1.23	1.17
T6M6	1.61	1.88	2.31
T6M9	1.36	1.68	1.96
T6PHl	1.70	0.96	1.25
T6PHr	1.85	0.88	1.20
T6M10	1.14	0.96	1.02
T6M11	1.08	1.68	1.75
T6SPL	1.13	5.29	5.64
T6TPW	1.39	4.99	4.23
T6IFlca	1.14	1.84	1.97
T6IFrca	1.14	1.80	1.69

T10M2	1.46	1.75	1.45
T10M1	1.30	1.54	1.75
T10M6	1.64	1.93	2.47
T10M9	1.17	2.54	2.35
T10PHl	1.52	1.38	1.70
T10PHr	1.39	1.43	1.68
T10M10	1.14	1.39	1.30
T10M11	1.24	1.54	1.71
T10SPL	1.09	4.30	4.13
T10TPW	1.13	5.01	4.73
T10lFlca	-2.21 *	1.67	1.12
T10lFrca	1.44	1.38	1.15
L1M2	1.00	2.04	2.04
L1M1	1.05	1.88	1.84
L1M6	1.63	2.07	2.64
L1M9	1.08	2.92	2.80
L1PHl	1.22	1.23	1.36
L1PHr	1.23	1.38	1.53
L1M10	1.63	1.22	1.55
L1M11	1.31	1.55	1.77
L1SPL	1.46	3.30	3.99
L1TPW	1.15	7.01	6.53
L1lFlcr	1.41	1.15	1.37
L1lFlca	1.15	1.55	1.45
L1lFrcr	1.35	1.12	1.30
L1lFrca	1.05	1.31	1.35
L5M2	1.55	2.24	1.79
L5M1	1.48	2.54	2.08
L5M6	1.02	2.66	2.68
L5M9	1.07	3.11	3.22
L5PHl	1.42	1.87	2.23
L5PHr	1.40	1.77	2.09
L5M10	1.57	2.38	1.90
L5M11	1.14	2.75	2.93
L5SPL	1.60	3.21	4.06
L5TPW	-2.51 *	16.72	10.56
L5lFlcr	1.84	0.94	1.14
L5lFlca	1.23	1.82	1.64
L5lFrcr	**3.26** **	0.71	1.28
L5lFrca	1.41	1.88	1.58
FMM16	1.62	2.74	3.49
FMM7	1.18	3.00	2.76
HLM1	**1.96** **	17.29	21.16
HCM7	**2.10** **	4.14	5.01
FHM18	**3.30** **	2.34	3.17
FLM1	**1.80** **	23.37	25.27
FCM8	**1.93** **	5.46	6.09
BIWM2	1.58	17.17	15.69

bold: increase (significants only)
*: significant before ($p<0.05$) /
**: after Bonferroni's correction

13. Partial correlation coefficients of variables with time before present and selected long bone measurements (variables with significant correlation with the selected long bone measurements only; whole sample)

Maximum femur length:

Variable - males	r	Variable - females	r
C3M2	0.22 *	C3M2	0.16
C3M1	**0.29** **	**C3M11**	**0.30** **
C3M11	**0.27** **	**C3IFLCR**	**0.38** **
C3TPW	0.15	**C3IFLCA**	**0.33** **
T1M2	0.14	C7M2	0.05
T1M1	0.03	C7M1	-0.14
T1M9	0.15	**C7M11**	**0.37** **
T1TPW	0.11	C7IFLCR	0.06
T6M2	0.04	T1M2	0.00
T6M1	-0.04	T6M2	0.01
T6M6	**0.37** **	T6M1	-0.11
T6PHL	0.08	T6M6	0.26 *
T6PHR	0.09	T6M9	0.01
T6TPW	-0.06	T6PHL	-0.18
T10M2	**0.26** **	T10M2	-0.11
T10M6	**0.38** **	T10M1	-0.02
T10M9	0.19 *	T10M6	0.19 *
L1M2	-0.14	T10M9	0.22 *
L1M6	0.24 *	T10PHL	-0.07
L1M9	0.23 *	T10PHR	-0.16
L5M2	-0.05	T10M11	0.14
L5M1	0.14	L1M2	-0.21 *
L5M9	-0.06	L1M1	-0.11
L5M6	0.15	L1M6	0.04
L5PHR	0.09	L1M9	0.01
L5M11	0.11	L1PHL	-0.09
L5TPW	0.15	L1M10	0.09
		L1M11	0.09
		L5M2	-0.14
		L5M1	0.05
		L5M6	-0.10
		L5M9	*-0.28* **
		L5PHL	-0.24 *

Humerus minimal circumference:

Variable - males	r	Variable - females	r
C7M2	0.13	C7M2	0.14
C7M6	0.14	C7M6	0.22 *
C7M9	-0.16	C7PHL	0.01
C7SPL	0.11		

*= significant before Bonferroni's correction ($p<0.05$)
**= significant after Bonferroni's correction ($p<0.05$)
Bold: increase (significants only)
italic: decrease (significants only)

14. Principal component analysis

Males

Total Variance Explained

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	19.100	20.538	20.538
2	11.479	12.343	32.881
3	5.558	5.976	38.857
4	4.756	5.114	43.971
5	4.292	4.616	48.587

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
C7M2	.741	-2.569E-02
C3M1	.737	-.141
T1TPW	.690	-.118
C3M2	.681	-.138
C3PHR	.673	-.399
C7M1	.673	-.119
T1PHL	.655	-.397
T6M2	.648	-.210
T1M10	.643	.425
C3PHL	.641	-.347
C3M11	.632	.315
T6PHR	.630	-.508
T1M2	.621	-.171
C7IFRCA	.601	.369
T1PHR	.600	-.226
T10M9	.600	-.244
T6PHL	.599	-.427
L5M9	.598	-.124
T6M6	.591	-.355
C7PHL	.585	-.211
L5IFRCR	.578	.345
T10M10	.573	.453
L5PHR	.561	-.294
T1IFRCA	.550	.435
L5IFLCR	.543	.140
T1IFLCA	.533	.328
C7PHR	.531	-.158
C3TPW	.524	2.211E-02
T10PHR	.521	-1.043E-02
L5M6	.513	-.457
T6TPW	.512	-4.289E-02

	Component	
	1	2
T10M2	.512	-2.884E-03
T10IFLCA	.511	.395
T1M1	.510	-.255
T6M9	.506	-.476
T1IFRCR	.479	.428
L5PHL	.477	-.315
C3M9	.473	1.548E-02
T1M11	.472	.260
L1PHL	.471	-.355
L1M2	.453	-1.163E-03
T10PHL	.453	-.143
L5TPW	.441	-7.968E-02
T1M6	.407	-.398
L1IFRCR	.406	.147
C3IFLCA	.384	.379
T10TPW	.330	-3.407E-02
L1M1	.292	-6.021E-02
L1M10	.450	.633
C7M10	.532	.602
L1IFLCR	.201	.583
T1IFLCR	.336	.582
T10M11	.424	.561
C3IFRCR	.251	.549
C3M10	.268	.545
T6M11	.268	.537
C7IFLCR	-6.648E-02	.524
L5M2	.381	-.519
L5M11	.470	.508
C7IFRCR	8.430E-02	.497
C3IFRCA	.374	.475
C3IFLCR	.207	.472
C7IFLCA	.391	.469
T10IFRCA	.356	.469
L1M9	.430	-.464
T10M6	.411	-.456
L1PHR	.448	-.452
L1M6	.265	-.441
C3M6	.424	-.433
L1IFLCA	.348	.427
C7M11	.328	.404
L1M11	.305	.404
L5M10	6.931E-02	.385
C3SPL	.178	-.344
L5SPL	-5.713E-02	-.110
T6M10	.182	.242

	Component	
	1	2
T1M9	.345	-.371
T6SPL	.143	-7.169E-02
T6IFLCA	.217	8.506E-02
C7M9	.377	-.226
C7M6	.389	-.390
T6IFRCA	9.026E-02	2.973E-02
T6M1	.283	-.360
L5M1	.346	-4.212E-02
T10M1	.171	9.265E-02
L1IFRCA	.384	.424
L1TPW	-8.837E-02	-1.991E-02
C7SPL	.271	6.763E-02
L1SPL	-4.656E-02	-8.793E-02
L5IFLCA	.297	.396
L5IFRCA	.138	.395
T1SPL	.203	.217
T10SPL	3.798E-02	-.155

Extraction Method: Principal Component Analysis.

a. 5 components extracted.

Females

Total Variance Explained

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	25.096	26.985	26.985
2	11.282	12.131	39.115
3	6.276	6.749	45.864
4	5.140	5.527	51.391
5	4.967	5.340	56.731

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
C3M2	.746	-.397
C3M1	.354	-.493
C3M6	.274	-.361
C3M9	.548	-7.784E-02
C3PHL	.684	-.352
C3PHR	.763	-.355
C3M10	.636	.321
C3M11	.647	.203
C3SPL	.157	6.055E-02
C3TPW	.499	-.251
C3IFLCR	.538	.329
C3IFLCA	.626	.444
C3IFRCR	.504	.510
C3IFRCA	.381	.384
C7M2	.808	-.253
C7M1	.724	-.213
C7M6	.547	-.325
C7M9	.372	-.373
C7PHL	.503	-.262
C7PHR	.551	-.249
C7M10	.634	.425
C7M11	.447	.333
C7SPL	6.012E-02	.277
C7IFLCR	.629	.249
C7IFLCA	.454	.626
C7IFRCR	.637	.488
C7IFRCA	.429	.614
T1M2	.801	-.249
T1M1	.648	-.250
T1M6	.492	-.229
T1M9	.149	-.450

Component Matrix[a]

	Component	
	1	2
T1PHL	.575	-.253
T1PHR	.676	9.149E-03
T1M10	.664	.400
T1M11	.487	.170
T1SPL	.348	-.185
T1TPW	.410	-.112
T1IFLCR	.572	.612
T1IFLCA	.498	.633
T1IFRCR	.623	.428
T1IFRCA	.440	.496
T6M2	.556	-.454
T6M1	.346	-.529
T6M6	.470	-6.339E-02
T6M9	.456	-.525
T6PHL	.630	-.246
T6PHR	.673	-.103
T6M10	.294	.212
T6M11	.570	2.183E-03
T6SPL	.186	2.837E-02
T6TPW	.510	-4.962E-02
T6IFLCA	.144	-.144
T6IFRCA	.406	8.234E-02
T10M2	.499	-.319
T10M1	.216	-.443
T10M6	.511	-.235
T10M9	.440	-.482
T10PHL	.588	-9.590E-02
T10PHR	.654	-.248
T10M10	.559	.396
T10M11	.719	-5.214E-02
T10SPL	.274	-.317
T10TPW	.427	.122
T10IFLCA	.202	.423
T10IFRCA	.289	.566
L1M2	.507	-.124
L1M1	.488	-.482
L1M6	.529	-.240
L1M9	.556	-.512
L1PHL	.653	-8.866E-04
L1PHR	.581	-.255
L1M10	.754	.231
L1M11	.576	-.187
L1SPL	.383	-.328
L1TPW	.189	-.406
L1IFLCR	.350	.397
L1IFLCA	.473	.637
L1IFRCR	.416	.245
L1IFRCA	.562	.500
L5M2	.406	-.193
L5M1	.448	-.137
L5M6	.668	-.217
L5M9	.669	-.117
L5PHL	.751	-5.708E-02
L5PHR	.817	-.157
L5M10	.373	.120
L5M11	.607	.143
L5SPL	7.559E-02	-.462
L5TPW	5.843E-02	6.868E-02
L5IFLCR	.478	.484
L5IFLCA	.165	.539
L5IFRCR	.419	.658
L5IFRCA	.268	.446

Extraction Method: Principal Component Analysis.

a. 5 components extracted.

Rühli, F.J., Schultz, M., and Henneberg, M., (2002) Microevolution of the central European human vertebral column since the Neolithic: preliminary osteometric assessment and interpretations.
American Journal of Physical Anthropology, suppl. 34, pp. 134-135.