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A decrease in diet quality occurs during pregnancy in overweight and obese women which is maintained post-partum

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Title: A decrease in diet quality occurs during pregnancy in overweight and obese women which is maintained post-partum

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Running title: Diet quality in overweight pregnant women

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Abstract

Background: Ensuring adequate dietary intake during pregnancy has important implications for optimising maternal and fetal health. It is not known whether diet quality is altered over pregnancy and the post-partum period.

Objective: The aim of this study was to perform a comprehensive assessment of diet quality in overweight and obese women during pregnancy and early post-partum.

Design: In a prospective cohort study, n=301 overweight or obese pregnant women completed a food frequency questionnaire at study entry (10-20 weeks gestation), 28 weeks gestation, 36 weeks gestation and 4 months post-partum for assessment of macronutrient and micronutrient intake and diet quality by the Healthy Eating Index (HEI).

Results: Energy, macronutrient and dietary sources of micronutrients did not alter across pregnancy or post-partum. The HEI was of below average quality in 31.0% of women at baseline. This decreased from week 28 ($P<0.001$) and was maintained at a lower level post-partum such that HEI levels were lower compared with study entry (53.3±12.7 versus 56.7±10.1, $P<0.001$). The HEI decrease occurred in association with decreases in the milk, meat and unsaturated oil components and increases in the proportion of energy from solid fats, alcohol and added sugars ($P<0.001$) and was independently predicted by the socioeconomic index for areas score ($\beta=-0.011$, SE=0.011, $P=0.031$).

Conclusion: We report for the first time that dietary quality decreases across pregnancy and is maintained at this reduced level in the early post-partum period in overweight and obese women. Dietary interventions aimed at improving diet quality should be targeted to early pregnancy and post-partum.

Key words: Diet quality, pregnancy, post-partum, overweight, obesity

Introduction

Nutritional status during pregnancy has important implications for the health of the woman and of her infant. This is well recognised with regards to the effect of under or over nutrition on health outcomes including gestational diabetes, maternal anaemia, hypertension, fetal growth and development, neural tube defects, infant cognitive and neurodevelopment, birth weight and potential long-term childhood disease risk [1-4]. Pregnancy is associated with increased nutritional needs [5]. While some women may have a nutritionally adequate diet, for others the degree to which they modify their diet during pregnancy is crucial in achieving these recommended requirements. While food intakes are variably reported to either be changed or unaltered over the course of pregnancy and into the post-partum period [6-8], optimal dietary intake is commonly not achieved across these life stages as assessed by comparison to micronutrient reference values, healthy eating indices or recommended food group intakes [9].

It is also important to assess the overall quality of a diet to identify eating patterns associated with disease prevention [10]. This can be analysed through identification of healthy or unhealthy food patterns through techniques including principle component analysis or use of dietary quality indices comparing nutritional intake with recommendations for healthy eating or dietary guidelines. As a comprehensive measure of total dietary intake, decreased diet quality assessed by these indices is associated with longitudinal weight gain [11] and increased both all cause mortality and morbidity, and specifically mortality related to chronic diseases including cancer and coronary heart disease [10]. Furthermore, poor diet quality during pregnancy and post-partum has been previously reported [9, 12] to be associated with adverse outcomes such as maternal glucose intolerance and preeclampsia [13]. There is limited data assessing longitudinal changes in diet during and after pregnancy. No changes in dietary patterns, assessed from

principle component analysis, were reported over pregnancy or over the post-partum period [14, 15]. However, it is unclear whether diet quality assessed through diet quality indices is modified longitudinally across pregnancy and the post-partum period.

There is additionally evidence that overweight and obese women consume a poorer quality diet during pregnancy with reduced grain, vegetable, iron and folate intake and poorer overall diet quality compared with women of healthy weight [16-18]. While it is estimated that up to 50% of Australian women are overweight or obese during pregnancy [19], there is limited data examining changes in diet specifically in this population of women. Woolf et al have reported increases in energy intake from 15 to 27 weeks [6], although to our knowledge there are no studies examining longitudinal changes in dietary quality in overweight and obese women through pregnancy and post-partum. The aim of this study was to perform a comprehensive assessment of energy, macronutrient and micronutrient intake, and dietary quality over the course of pregnancy and post-partum in overweight and obese women.

Methods

Study population

This prospective cohort study is nested within a randomised trial evaluating the effect of an antenatal dietary and lifestyle intervention to limit weight gain for women who are overweight or obese (the LIMIT study). The methodology of the LIMIT randomised trial has been described in detail previously [20]. Specifically, women who were randomised to the control group of the LIMIT trial between September 2008 and January 2010, who received standard antenatal care and completed dietary questionnaires at all 4 time points of the study comprise the current cohort (n=301). Inclusion criteria were women with a body mass index (BMI)≥25 kg/m^2 with a live singleton pregnancy between 10^{+0} to 20^{+0} weeks gestation at their

first antenatal appointment. Women diagnosed with diabetes (pre-existing Type 1 or Type 2 or gestational diabetes prior to trial entry) were excluded from the study. Women were recruited from public maternity hospitals across the South Australian metropolitan area (specifically, Women's and Children's Hospital, Lyell McEwin Hospital and Flinders Medical Centre). While all women received informal advice regarding healthy eating from their midwife, at one recruitment site (Lyell McEwin Hospital) women with a BMI > 40 kg/m^2 additionally received a pamphlet on healthy eating principles. Ethics approval was obtained from all sites, and all women provided written informed consent. This trial was registered at the Australian and New Zealand Clinical Trials Registry (ACTRN12607000161426).

Demographic and clinical measurements

Baseline demographic details were collected including postcode and socioeconomic indices for areas disadvantage score (SEIFA) [21], parity, age, ethnicity, smoking status at time of recruitment and gestational age and weight at entry. At the time of study entry, all women had their height and weight measured, and BMI calculated and categorised according to World Health Organisation criteria [22].

Food Frequency Questionnaire

Women completed the Harvard Semi-quantitative Food Frequency questionnaire (The Willett Questionnaire) at study entry, 28 and 36 weeks gestational age and 4 months post-partum. The Willett questionnaire was developed in 1985 in the United States to measure the daily intake of 18 selected nutrients from 126 food items with an indication of standard portion size divided into seven food groups [23]. It has been validated for use across diverse study populations including pregnancy [24-26] and at multiple time points across pregnancy [27] using

24-hour recalls, biomarkers or 4-day weighed food records and is appropriate for performing nutrient estimates in this population. Questions were asked about relative frequency of food item consumption, use of supplements, cooking methods and addition of sugar to foods. An open ended question allowed respondents to record consumption of other foods not included on the food list which was then categorized by study investigators into the appropriate food categories. Daily nutrient intakes were estimated by multiplying frequency responses by the nutrient compositions of the specified portion size of each food items according to the Willett nutrient database (Harvard SSFQ5/93; Harvard School of Public Health, Boston, Massachusetts).

Nutrients were analysed as mean intakes and as energy-standardised intake per 1000 kcal. For the questionnaire completed at study entry, women were asked to indicate how often on average they consumed the amount of food during the past year (for trial entry data) or since the previous questionnaire was completed (for 28 and 36 weeks gestational age and 4 months post-partum data). If missing data exceeded 25% the questionnaire was excluded from the analysis. Women who reported unrealistic energy intakes (<4,500kJ/day or >20,000kJ/day) were excluded from analysis as previously reported for pregnant women [28].

Nutrient comparison

Nutrient intake values obtained from the Willett questionnaire were compared with the Australian Nutrient Reference Values [5]. The Recommended Dietary Intake (RDI) and Adequate Intake (AI) were used to determine adequate intake for the population group. The RDI is defined as the average daily dietary intake that is sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals in a particular life stage and gender group.. Where a RDI was not set, AI was used which is based on observed or experimentally

151 determined approximations of nutrient intake by a group (or groups) of apparently healthy
152 people that are assumed to be adequate [5].
153
154
155 *Healthy eating index*
156 The 2005 Healthy Eating Index (HEI), developed by the US Department of Agriculture, was
157 used as a measure of diet quality and variety [29]. It consists of 12 components which are all
158 given a score to a maximum score of 100. The first 6 components, total fruit (including 100%
159 juice), whole fruits (excluding juice), total vegetables, dark green and orange vegetables,
160 vegetables and legumes (legumes included as a vegetable only after the Meat and Beans
161 standard was met), total grains and whole grains categories have a score out of five. The next
162 five components milk (all products made from cow's and goat's milk and soy beverages and
163 excluding infant formulas and products that are primary fat such as butter, cream, sour cream
164 and cream cheese), meat and beans (meat products, eggs, nuts, seeds, soy-based products and
165 legumes), oils (fats that are liquid at room temperature, from a plant source and not described
166 as 'hydrogenated' or 'shortening' including oils from plant, fish, nuts and seeds or
167 margarines), saturated fat and sodium have scores out of 10. The final component of the HEI
168 includes calories from solid fats (all excess fat from the Milk and Meat and Beans
169 components beyond that would be consumed if only the lowest fat forms were eaten, solid
170 fats added to foods in preparation or at the table including cream, butter, stick margarine,
171 regular or low-fat cream cheese, lard, meat drippings, cocoa and chocolate), alcoholic
172 beverages and added sugars (SoFAAS) and has a score out of 20. A HEI score above 80 is
173 considered good, a score between 50-80 needs improvement and scores below 50 are
174 considered poor with these scoring criteria determined by the proportion of people within
175 these categories meeting nutrient sufficiency (defined as meeting 75% of the recommended

dietary allowances) on the development of the original HEI [30]. The HEI has been validated for use in a pregnant population [31].

Statistical analysis

Data are presented as mean±standard deviation (SD) except where indicated. Data transformations were not used to correct for any departures from normality, since the sample size was sufficient for the central limit theorem to apply [32]. Two-tailed statistical analyses were performed using SPSS (SPSS for Windows, Rel. 18.0.18. 2010. Chicago: SPSS Inc) with statistical significance set at a P value of <0.05. Cross-sectional comparisons for women included or excluded from the study were analysed using independent sample t-tests. Comparisons between time points were assessed using repeated measures analysis of variance (ANOVA) with parity, BMI category, SEIFA category, breastfeeding, hospital recruitment site or trimester at trial entry as between subject factors. As the Australian food supply was fortified with folic acid from September 2009, this was adjusted for in statistical analysis by incorporating month of recruitment (pre or post September 2009) as a between subject factor for folate intake. Relationships between variables were examined using bivariate correlations and multiple linear regression.

Results

Participant Characteristics

301 women randomised to the control group of the LIMIT trial were recruited who completed the Willett questionnaires at all four time points. N=10 were excluded from all analyses due to unrealistically low energy consumption, leaving 291 participants (96.7 %) included in the data analysis. Compared to the n=10 women excluded from the study, women included in the study had a trend for increased age (30.5±5.0 versus 27.8±2.0 years, P=0.06) and decreased

BMI (31.6±5.5 versus 35.1±2.5 kg/m^2, P=0.052) and had higher parity (0.9±0.9 versus 0.6±0.2, P<0.001) and were from an area of greater social disadvantage (5.0±2.9 versus 6.5±2.6, P<0.001) (Table 1). Baseline characteristics of women are presented in Table 1 and are similar to the reported demographic characteristics of all pregnant women of any BMI in South Australia [33]. The mean gestational age at study entry was 16.8±4.9 weeks with 22.5% of women in the first trimester and 77.5% of women in the second trimester of pregnancy. At 4 months post-partum, 57% of women were breastfeeding (165/291), 32% were not breastfeeding (95/291) and breastfeeding status was unknown for 11% of women (31/291).

Healthy Eating Index

There was a significant change of the HEI during pregnancy and post-partum (Table 2). HEI declined significantly between study entry and 28 weeks' gestation (P<0.001) and was maintained at this lower level at 4 months post-partum (P<0.001) reflected by significant changes in the milk, meat, oil, and energy from SoFAAS scores. The milk and meat scores of the HEI also significantly decreased between study entry and 28 weeks' gestation (P<0.001) and were maintained at this lower level at 4 months post-partum for the meat score (P<0.001). The energy from SoFAAS scores of the HEI decreased between study entry and 28 weeks' gestation (P<0.001), decreased further from 36 weeks gestation to 4 months post-partum (P<0.001) predominantly related to an increase in alcohol consumption post-partum and were maintained at this lower level at 4 months post-partum (P<0.001). This indicates an overall decrease in milk and meat and increase in calories from SoFAAS over the entire study duration. The oil score of HEI declined significantly between study entry and 28 weeks' gestation (P<0.001), followed by a further decline to 36 weeks' gestation (P<0.001), representing a decrease in non-saturated oils. The oil score increased further at 4 months post-partum (P<0.001) but remained significantly lower than that reported at baseline (P<0.001).

There was no significant effect on further analysis for BMI, parity, SEIFA, hospital recruitment site or trimester at trial entry as between group factors. At study entry HEI correlated significantly with age (r=0.21 P<0.001) but none of the other baseline covariates. On adjustment for breast-feeding status, there was a significant difference in change in HEI for the total score (P<0.001) and the calories from SoFAAS scores (P<0.001). This occurred from 36 weeks gestation to 4 months post-partum for both the total score and calories from SoFAAS (P<0.001) such that the women who were breastfeeding had a decrease in total HEI (P<0.001) and a increase in calories from SoFAAS (P<0.001) compared to no significant change in total HEI (P=0.220) and calories from SoFAAS (P=0.100) for the women who were not breastfeeding.

A multiple linear regression model was constructed to assess independent predictors of the change in HEI from trial entry to 4 months post-partum including age, BMI, ethnicity, smoking, parity, SEIFA, breastfeeding status, hospital recruitment site or trimester at trial entry. SEIFA socio-economic score was the only significant predictor of the change in dietary quality (β=-0.011, SE=0.011, P=0.031). A 1 unit increase in SEIFA, reflecting improved social advantage, was associated with a 0.011 decrease in the change in HEI.

Macronutrients and micronutrient intake

Energy intake did not change over the entire study duration and was not significantly different between trial entry and post-partum (8209.3±2533.4 versus 8226.1±2546.0 kJ/day, P=0.179). There was no significant change in the intake of the majority of macronutrients over the course of pregnancy and 4 months post-partum (Table 3). Alcohol consumption declined significantly between study entry and 28 weeks' gestation (P<0.001), followed by a small but significant increase to 36 weeks' gestation (P<0.001), before increasing at 4 months post-

partum to levels similar to baseline (P<0.001). There was a significant change in caffeine consumption due to an increase from 36 weeks gestation to 4 months post-partum (P<0.001). There was no significant effect on further analysis for BMI, parity, SEIFA, hospital recruitment site or trimester at trial entry. On adjustment for breast-feeding status, there was a significant difference for the change in energy (P<0.001), protein (P=0.008) and fat (P<0.001) intake. This occurred from 36 weeks gestation to 4 months post-partum for energy (P<0.001), protein (P=0.008) and fat (P<0.001) such that the women who were breastfeeding had a increase in energy (P<0.001), protein (P=0.001) and fat (P=0.001) compared to no significant change in energy (P=0.237), protein (P=0.088) and fat (P=0.069) for the women who were not breastfeeding.

For micronutrient intake from both dietary and supplement sources, a significant change was observed for calcium, iron, zinc, vitamin A equivalents, niacin, vitamin B6, vitamin C, and folate over the entire study duration (Table 3). For calcium, iron, zinc, vitamin A equivalents, vitamin B6 and vitamin C, a decrease was observed from 36 weeks gestation to 4 months post-partum. A similar pattern in supplement use was observed over this time period. Supplement use remained stable over pregnancy with 33.7% of women taking supplements at study entry, 30.5% at 28 weeks gestation and 29.9% at 36 weeks gestation. Supplement use then declined in the post-partum period (P<0.001) to 24.4% which was significantly lower than baseline levels (P<0.001). For niacin and folate, a decrease in intake was observed from study entry to 28 weeks gestation followed by a further decrease from 36 weeks gestation to 4 months post-partum. There were no changes in any micronutrient intake from dietary sources alone over the entire study duration. These results were maintained following further analysis for adjusted nutrient intake (per 1000 kcal) (data not shown). There was no significant effect on further analysis for BMI, parity, SEIFA, hospital recruitment site or trimester at trial entry.

When adjusting for recruitment pre or post September 2009 to account for mandatory fortification of the Australian food supply with folic acid, no significant differences for folic acid intake from dietary sources alone or from dietary and supplement sources was reported (data not shown).

Comparison of dietary intake with recommendations

A comparison of HEI and macronutrient and micronutrient (dietary and supplement) intake is presented in Table 4. High or average HEI scores were present for 69% at trial entry, 65% of women at 28 weeks' gestation, 58.4% at 36 weeks' gestation, and 54% at 4 months post-partum, indicating a modest deterioration in diet quality. The majority of the women had intakes of most macro- and micronutrients equivalent to or above the recommendations at all time points with the exception of fibre, magnesium, manganese, pantothenic acid, and copper. With regards to key pregnancy related micronutrients, over 40% of women did not consume sufficient iron or calcium during pregnancy while adequate folate was consumed by over 80% of women in the first trimester which decreased to 65-71% at week 36 for women recruited either before or after September 2009.

Discussion

This study supports previous reports of poor diet quality during pregnancy and post-partum for overweight or obese women [9, 17, 18, 31, 34]. We furthermore expand this literature to report for the first time that dietary quality significantly decreased across pregnancy and was not improved during the post-partum period in overweight and obese women.

We report here similar energy and macronutrient intake to previous studies assessing women in pregnancy or post-partum [7-9]. As previously reported, no changes in energy or

301 macronutrient intake occurred from the early second trimester to post-partum [35] with the
302 exception of alcohol [7]. Supplement use was low and micronutrient intake poor for key
303 pregnancy related micronutrients including iron and calcium. While poor diet quality was
304 present only in 31% of women at trial entry, this increased to nearly 50% of women post-
305 partum with fruit and vegetable scores comprising on average 60%, milk and dairy 50% and
306 total grains 40% of the maximum score. This is in contrast to previous studies which have
307 reported higher intakes of grains and meat post-partum [34] in overweight or obese women.
308 However, we confirm findings of a poor milk, meat and whole grains and fruit and vegetable
309 intake [18, 34] and elevated consumption of SoFAAS [18, 34] in pregnancy and post-partum.
310
311 We report here for the first time a decrease in diet quality over pregnancy in overweight and
312 obese women which was maintained post-partum. This is consistent with previous reports of a
313 negative correlation between HEI and week of gestation [18]. However, other research reported
314 no differences in the HEI between women who were pregnant, post-partum or not pregnant [9,
315 31]. The decrease in diet quality was independently inversely associated with SEIFA indicating
316 a lesser decrease in diet quality was associated with decreased social disadvantage consistent
317 with previous inverse associations between diet quality and income and education [38]. We note
318 the use of SEIFA as a surrogate of socioeconomic status which should not be used as a proxy
319 measure for individual or familial disadvantage [21] and the contribution of factors such as
320 income, education or occupation to dietary changes across pregnancy warrant assessment in
321 future studies. In contrast to previous research [17], we observed no association between BMI
322 and diet quality. This may be because all the women in this current study were overweight or
323 obese. However, these results cannot be specifically attributed to the overweight and obesity
324 status of these women as we lack a comparative population of women of healthy weight.
325 Alternatively, our findings may be indicative of an indirect relationship between BMI and diet

quality partially mediated by factors including socioeconomic status. While some research reports a lack of change in dietary patterns across pregnancy [15], others suggest changes may occur following women learning they are pregnant, after receiving counseling at the initial prenatal visit, or following resolution of nausea or vomiting after the 1st trimester [7]. At trial entry women were either in the first (23%) or second trimester (78%). While this introduces potential bias relating to modified dietary intake in association with increased likelihood of nausea with early pregnancy [36] or greater modification of diet in the second trimester following a longer period of being aware of their pregnancy, we note no difference in our statistical analysis on adjustment for trimester at trial entry.

The reduction in diet quality in this study was contributed to by a decrease in milk and meat intake consistent with some [39, 40] but not all previous studies [7, 14, 39]. This may be related to specific food avoidances in pregnancy with an increased aversion to meat and fish (27% and 4% of women) previously reported [40] and an increased proportion of pregnant women avoiding raw meat, fish, shellfish and milk cheese and organ meat compared to non-pregnant women [41]. Recent Australian data has also reported pregnant women with a lower intake of Listera-containing foods have lower micronutrient intakes [42], suggesting greater avoidance of foods from the milk, meat and unsaturated oils components may be related to a greater avoidance of potential sources of Listeria monocytogenes. We also observed an increase in the proportional intake of calories from SoFAAS consistent with previous reports of an increase in a high energy diet score during pregnancy but no change in a prudent diet score [14] and lower alcohol intake in pregnant compared to non-pregnant women [41]. A lack of improvement in diet quality during pregnancy has been previously proposed to be related unplanned pregnancies which do not allow sufficient time for positive nutritional changes [43]. In this current study the decrease in diet quality primarily occurred from early pregnancy to 28 weeks gestation, highlighting

early pregnancy as a critical stage for targeting dietary interventions. The lack of improvement in diet quality following birth is not surprising given that the post-partum period is associated with challenges in achieving a healthy diet in addition to adjusting to life with a new baby [44]. Furthermore, breast feeding status was associated with decreases in diet quality and increases in total energy, protein, fat and calories from SOFAAS from late gestational to post-partum in keeping with previous reports of poorer diet quality [34] or higher energy intake or discretionary calories [37] for women who were breastfeeding compared to not breastfeeding. It is possible that more positive dietary changes may be initiated subsequently, supported by reports of decreases in energy intake at 6-12 months post-partum [45].

In our study, micronutrient intake was insufficient for many women consistent with previous findings [9, 31, 46]. In particular, over 40% of women did not consume an adequate iron or calcium intake from both dietary and supplement sources during pregnancy and post-partum, with implications for the development of anaemia [47]. Micronutrient intake from both dietary and supplement sources declined over the course of our study. Previous Australian studies have reported higher levels of supplementation in the first trimester of pregnancy [48] in keeping with national recommendations for folate supplementation [5]. This may reflect the gestational age at which women were recruited to the study, and current recommendations indicating supplementation to continue only during the first trimester of pregnancy. Our finding of a key contribution of supplement use to micronutrient intake in pregnancy is also consistent with previous reports [49, 50], highlighting the need for both appropriate education, particularly in relation to dietary sources of micronutrients.

The strengths of our study include the comprehensive assessment of dietary intake encompassing energy, macronutrient and micronutrient intake and diet quality. The

participants were relatively similar to population data for South Australian pregnant women, indicating the generalisability of this data. We prospectively collected food, nutrient and supplement intake information at multiple time points during pregnancy and after birth, reducing inter individual variability and capturing longitudinal changes in dietary intake. While standard antenatal care differed between the hospital recruitment sites which could potentially result in differences in dietary intake, we note this did not affect our analysis for the HEI, macronutrient intake or micronutrient intake. We utilised a FFQ in contrast to more intensive assessments of food intake, as this was considered a tool preferable given the study duration and costs associated with the large sample size of the complete study (n=2180 women) [51]. The Willett FFQ has been previously validated and utilised in pregnancy [24-26] including in Australian pregnant women [52] and in a longitudinal way facilitating comparison over multiple time points [27]. However, the applicability of the Willett FFQ to the Australian food supply depends on the similarity of the food supplies with regards to factors including levels of food fortification. As our study recruitment overlaps the time frame for Australian mandatory fortification for folic acid (September 2009), an overestimation of folate intake may be possible for women recruited prior to September 2009 although we note no differences on accounting for this in statistical analysis.

The implications of poor diet quality extend beyond previous associations with micronutrient insufficiency [53]. Unhealthy dietary patterns or poor diet quality are associated with post-partum weight retention [34] and increased gestational weight gain [54]. This has important implications for long-term maternal obesity given the association between post-partum weight retention and longitudinal obesity development [55] and future assessment of the associations between change in dietary quality, gestational weight gain and post-partum weight retention is warranted. A poor diet quality post-partum may also contribute to an inadequate

preconception nutritional intake for the subsequent pregnancy. Furthermore, the implications for improving dietary quality extend beyond the health of the woman with positive associations reported between maternal and childhood diet quality [56]. While the clinical benefits of improving dietary quality and minimising excess gestational weight gain in overweight and obese pregnant women remain unclear [19], general advice on optimising dietary quality is warranted. The association between a deterioration in diet quality across pregnancy and increasing social disadvantage highlights the need for specifically targeted interventions during pregnancy for this population of women.

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Conflict of interest

All authors declare no conflicts of interest.

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Tables

Table 1. Demographic variables of included and excluded participants and comparative population data

Category with Mean±SD		Included N=291		Excluded N=10		Population data (S.A. 2009)
		N	%	N	%	%
Age:	<20 years	3	1.0	1	10.0	4.1
	20-30	124	42.6	5	50.0	44.3
	30-40	154	52.9	3	30.0	47.8
	40+	10	3.4	1	10.0	3.8
Parity:*	0 births	120	41.2	7	70.0	41.6
	1-2	159	54.6	3	30.0	49.9
	3+	12	4.1	0	0.0	8.5
BMI:	Overweight	136	46.7	4	40.0	54.1^
	Obesity I	87	29.9	2	20.0	25.8
	II	42	14.4	1	10.0	12.1
	III	26	8.9	3	30.0	8.0
Smoker:*	Yes	28	9.6	1	10.0	15.9
	No	259	89.0	0	0.0	82.6
	Unknown	4	1.4	9	90.0	1.5
Ethnicity:*	Caucasian	269	92.5	10	100.0	85.0
	Asian	11	3.7			8.1
	African	3	1			-
	Aboriginal	4	1.4			3.1
	Others	4	1.4			3.8

SEIFA:*	1-2 deciles[#]	80	27.5	0	0.0	20
	3-4 deciles	65	22.3	4	40.0	20
	5-6 deciles	43	14.8	1	10.0	20
	7-8 deciles	54	18.6	2	20.0	20
	9-10 deciles	49	16.8	3	30.0	20

651 Data are presented as mean±SD or % and were analysed by independent t-test with participant
652 inclusion/exclusion in the study as the between subject variable
653 * Significant difference between women included or excluded in the study
654 ^ Percentage calculated exclude underweight and normal weight women
655 # SEIFA Decile 1 contains the bottom 10% of the collection districts, Decile 2 contains the
656 next 10% and so on.
657 BMI = Body mass index, SA = South Australia, SD = Standard deviation, SEIFA = Socio-
658 Economic Indexes for Areas
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660 Table 2: Healthy eating index in overweight and obese women during pregnancy and post-partum

	Early pregnancy	28 weeks gestation	36 weeks gestation	4 months postpartum	P Overall effect of time
HEI (range 0-100)	56.7±10.1	54.0±10.3*	54.0±9.7	53.3±12.7#	<0.001
Total fruit (range 0-5)	2.7±1.6	2.7 ±1.5	2.7 ±1.5	2.5±1.5	0.111
Whole fruit (range 0-5)	3.0 ±1.7	3.1±1.7	3.1±1.6	2.7±1.8	0.082
Total vegetables (range 0-5)	3.3±1.4	3.3±1.5	3.2±1.4	3.5±1.3	0.115
Dark green and orange vegetables and legumes (range 0-5)	3.0±1.4	3.0±1.4	2.9±1.5	3.0±1.2	0.537
Total grains (range 0-5)	2.0±0.4	2.0±1.5	2.0±0.5	2.0±0.7	0.093
Whole grains (range 0-5)	0.9±0.1	0.9±0.1	0.9±0.1	0.9±0.1	0.325
Milk (range 0-10)	5.0±2.6	4.7±2.6*	4.5±2.3	4.6±2.4	<0.001
Meat (and beans) (range 0-10)	5.5±2.4	4.6±2.6*	4.4±2.6	4.4±2.6#	<0.001
Oils (range 0-10)	3.7±3.7	3.0±2.4*	2.9±2.4*	3.7±2.4*#	<0.001
Saturated fat (range 0-10)	4.6±3.0	4.7±3.0	4.5±3.2	4.9±3.0	0.526
Sodium (range 0-10)	8.0±2.6	7.8±2.7	7.6±2.8	7.4±3.0	0.646

Calories from SoFAAS (range 0-20 points)	17.8±6.3	15.8±4.8*	15.1±5.8	9.6±9.1*#	<0.001

Data are presented as mean±SD and were analysed by repeated measures ANOVA

* Significantly differently from preceding time

Significant difference compared to baseline measurements

HEI = Healthy eating index, SoFAAS = Solid fats, alcohol and added sugars

676 Table 3: Macronutrients and micronutrients in overweight and obese women during pregnancy and post-partum

	Trial entry	28 weeks gestation	36 weeks gestation	4 months postpartum	P Overall effect of time
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	
Macro-nutrients					
Energy (kJ)	8209.3±2533.4	8310.5±2469.1	8408.4±2561.1	8226.1±2546.0	0.179
Protein (g)	89.8±32.2	88.6±29.2	90.6±30.9	91.5±30.1	0.435
Total fat (g)	68.8±26.9	70.2±24.2	70.8±24.7	69.1±24.6	0.653
Carbohydrates (g)	245.6±86.8	257.2±92.1	259.6±96.4	242.9±89.3	0.085
Fibre (g)	21.7±9.6	22.3±9.8	22.5±10.2	22.3±9.7	0.358
Saturated fat (g)	25.9±10.8	26.8±9.9	27.4±10.2	26.0±9.7	0.811
Monounsaturated fat (g)	25.2±10.3	25.6±9.0	25.8±9.3	25.3±9.3	0.095
Polyunsaturated fat (g)	11.0±4.4	11.1±4.4	10.8±4.1	11.0±4.4	0.750

Cholesterol (g)	272.7±116.5	277.7±108.34	285.0±120.9	289.7±118.8	0.622
Alcohol (g)	3.6±8.3	0.4±1.1*	0.5±1.8*	3.3±7.4*	0.013
Micro-nutrients					
Caffeine (mg)	125.1±133.6	122.9±122.8	126.2±129.3	169.9±163.2*#	<0.001
Sodium (mg)	1851.3±673.8	1896.2±829.5	1945.9±813.9	1961.9±686.0	0.556
Calcium(mg)	1102.1±455.4	1140.6±465.2	1181.9±476.7	1009.1±454.6*#	0.035
Calcium WOS (mg)	901.1±405.6	944.6±447.8	1004.5±458.5	958.8±436.3	0.225
Iron (mg)	36.0±23.5	37.0±25.5	38.2±27.7	22.1±19.1*#	<0.001
Iron WOS (mg)	14.0±5.9	14.2±6.9	14.4±7.3	14.0±5.1	0.510
Zinc (mg)	31.9±22.0	29.8±19.2	29.4±20.4	18.1±14.9*#	<0.001
Zinc WOS (mg)	12.3±5.4	12.2±5.2	12.7±6.6	12.6±4.4	0.367
Magnesium (mg)	321.2±126.4	309.7±128.7	320.1±142.3	326.2±120.5	0.466
Magnesium WOS (mg)	319.7±124.9	308.8±127.9	318.8±14	325.1±119.5	0.368
Phosphorous (mg)	1350.5±498.7	1357.6±529.1	1431.2±607.3	1414.4±495.6	0.299
Phosphorous WOS (mg)	1349.7±498.0	1357.6±529.1	1431.2±607.3	1413.8±495.2	0.188
Potassium (mg)	3346.1±1263.7	3255.9±1363.2	3349.9±1375.9	3423.1±1211.1	0.745

Potassium WOS (mg)	3345.6±1263.4	3255.3±1363.0	3349.9±1375.9	3421.5±1210.4	0.752
Manganese (mg)	3.7±1.7	3.4±1.6	3.5±1.7	3.7±1.6	0.563
Manganese WOS (mg)	3.6±1.7	3.4±1.6	3.5±1.7	3.6±1.5	0.834
Copper (mg)	1.3±0.5	1.3±0.5	1.3±0.5	1.3±0.5	0.274
Copper WOS (mg)	1.3±0.4	1.3±0.5	1.3±0.5	1.3±0.5	0.875
Vit A active equiv (µg)	1828.1±913.1	1810.6±961.3	1785.1±836.4	1618.3±1026.7*#	0.018
Vit A active equiv WOS (µg)	1192.4±615.1	1212.3±733.3	1186.7±663.2	1281.9±662.9	0.362
Total carotene (µg)	16886.0±10138.1	16574.4±11275.9	15693.4±10325.7	17196.9±9819.0	0.635
Total carotene WOS (µg)	16773.0±10275.9	16645.5±11345.9	15924.3±10523.3	18201.1±9932.6	0.395
Retinol (µg)	3288.7±2255.7	3244.9±2448.5	3211.0±2164.2	2499.5±2901.2	0.088
Retinol WOS (µg)	1415.1±948.3	1519.9±1472.2	1561.9±1236.2	1487.3±1198.2	0.073
Vit B1 (mg)	5.2±10.5	4.6±9.0	4.5±9.2	2.9±6.6*#	0.017
Vit B1 WOS (mg)	1.5±0.5	1.5±0.5	1.5±0.6	1.5±0.5	0.070
Vit B2 (mg)	5.6±10.5	5.1±9.1	5.0±9.2	3.5±6.6*#	0.016
Vit B2 WO supp (mg)	1.9±0.7	2.0±0.8	2.1±0.8	2.0±0.7	0.066
Niacin (mg)	39.0±19.4	36.8±17.2*	36.3±18.6	29.6±15.7*#	<0.001

Niacin WOS (mg)	21.8±9.1	21.2±8.8	21.8±10.5	22.6±7.9	0.673
Vit B6 (mg)	7.6±17.8	7.1±19.2	6.6±14.5	4.3±13.1*#	0.028
Vit B6 WOS (mg)	2.1±0.8	2.1±0.8	2.1±0.8	2.1±0.7	0.822
Vit B12 (µg)	11.0±11.9	10.6±11.6	10.3±10.2	7.9±8.7	0.092
Vit B12 WOS (µg)	5.4±3.3	5.5±4.7	5.8±4.9	5.4±3.8	0.185
Pantothenic acid (mg)	7.5±9.9	7.4±9.6	7.2±8.7	7.2±7.2	0.954
Pantothenic acid WOS (mg)	5.3±2.0	5.2±2.1	5.4±2.1	5.4±1.9	0.645
Vit C (mg)	238.1±129.9	232.3±151.6	231.1±128.6	181.9±135.1*#	0.002
Vit C WO supp (mg)	154.0±87.6	147.9±97.6	147.4±100.4	141.2±79.5	0.624
Vit E (mg)	14.0±19.4	12.9±18.2	13.9±27.0	11.2±17.7	0.583
Vit E WO supp (mg)	7.2±3.0	6.9±3.0	7.1±3.5	7.3±2.8	0.763
Folate (µg)	1940.0±1163.3	1721.2±1194.9*	1636.2±1221.0	893.0±941.4*#	<0.001
Food folate (µg)	285.3±128.6	272.4±134.1	276.1±142.9	283.4±130.5	0.453

Data are presented as mean±SD or % and were analysed by repeated measures ANOVA

* Significantly differently from preceding time

693 # Significant difference compared to baseline measurements

694 Equiv = Equivalents, Supp = Supplement, Vit = Vitamin, WOS =Without supplementation

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708 Table 4: Comparison of intake (supplement and dietary) with recommendations from the Nutrient Reference Values and Healthy Eating Index

Food groups/Nutrients	Rec (Pregnancy)[a]	TE			28 weeks gestation			36 weeks gestation			Rec (Breastfeeding)	4 months post-partum		
		% Below	% Met	% Above	% Below	% Met	% Above	% Below	% Met	% Above		% Below	% Met	% Above
Energy (kj)	6100-17200[b]	19.2	79.4	1.4	19.2	80.5	0.3	17.9	81.8	0.3	6100-17200[b]	20.9	78.8	0.3
Protein (g)	60	15.8	84.2	-	17.5	82.5	-	12.7	87.3	-	70	14.8	85.2	-
Alcohol (g)	0[c]	-	54.3	45.7	-	83.5	16.5	-	83.2	16.8	-	-	-	-
Fibre (g)	28[d]	77.7	22.3	-	77.0	23.0	-	75.9	24.1	-	30	74.6	25.4	-
Calcium (mg)	1000-2500	44.7	55.0	0.3	45.0	54.3	0.7	39.2	60.1	0.7	1000-2500	54.3	45.4	0.3
Iron (mg)	27-45	41.2	33.4	25.4	42.3	29.5	28.2	43.6	26.2	30.2	9-45	59.4	29.6	11.0
Zinc (mg)	11-40	14.4	60.1	25.5	15.0	60.6	24.4	20.2	55.5	24.3	12-40	31.8	58.6	9.6
Magnesium (mg)	350	66.3	33.7	-	67.0	33.0	-	68.4	31.6	-	310	61.5	38.5	-
Phosphorous (mg)	1000-3500	21.9	72.1	-	21.9	72.1	-	20.2	79.7	0.1	1000-4000	19.9	80.1	0.3

Potassium (mg)	2800[d]	32.0	68.0	-	38.5	61.5	-	35.7	64.3	-	3200	33.3	66.7	-
Sodium (mg)	460-2300[d]	1.7	76.4	21.9	1.4	74.2	24.4	0.3	73.6	26.1	460-2300	0.7	68.4	30.9
Manganese (mg)	5[d]	81.4	18.6	-	83.1	16.9	-	83.1	16.9	-	5	79.0	21.0	-
Copper (mg)	1.3-10[d]	56.0	44.0	0	58.4	41.6	0	59.8	40.2	0	1.5-10	54.3	45.7	0
Folate (µg) for pre Sep 2009	600	10.1	89.9	-	19.3	80.7	-	28.6	71.4	-	500	45.7	54.3	-
Folate (µg) for post Sep 2009	600	17.7	82.3	-	26.3	73.7	-	35.5	64.5	-	500	51.9	48.1	-
Vitamin C (mg)	60-1000	3.8	96.2	0	4.5	94.8	0.7	3.4	96.6	-	85-1000	7.6	92.1	0.3
Vitamin B1 (mg)	1.4	16.8	83.2	-	16.5	83.5	-	20.3	79.7	-	1.4	34.0	66.0	-
Vitamin B2	1.4	7.6	92.4	-	5.8	94.2	-	6.5	93.5	-	1.6	15.8	84.2	-

(mg)														
Niacin (mg)	18	11.7	88.3	-	11.3	88.7	-	14.8	85.2	-	17	22.3	77.7	-
Vitamin B6 (mg)	1.9	14.8	85.2	-	15.1	84.9	-	15.8	84.2	-	2.0	29.6	70.4	-
Vitamin B12 (µg)	2.6	2.7	97.3	-	3.4	96.6	-	4.5	95.5	-	2.8	8.9	91.1	-
Vitamin A (µg)	700-3000	8.9	81.1	10.0	10.0	82.1	7.9	8.3	84.8	6.9	1100-3000	14.1	78.3	7.6
Pantothenic acid (mg)	5[d]	46.7	53.3	-	48.5	51.5	-	42.6	57.4	-	6	42.6	57.4	-
Vitamin E(mg)	7-300[d]	19.9	80.1	0	27.1	72.9	-	25.8	74.2	-	11-300	41.6	58.4	-
		Low	Av	High	Low	Av	High	Low	Av	High		Low	Av	High
HEI	High >80 Av 50-	31.0	68.7	0.3	35.0	58.5	6.5	41.3	56.9	1.7	High >80 Av 50-79.9	45.9	53.1	1.0

	79.9 Low <50										Low <50			

Data are presented as %

a: Recommended Dietary Intake (RDI) adapted from the Australia National Health and Medical Research Council (NHMRC) recommendations [5]

b: With different age and physical activity level

c: NHMRC recommends no alcohol intake during pregnancy

d: Adequate Intake used when an RDI cannot be determined

714 Av = Average, HEI = Healthy eating index, Rec = Recommendations, TE= Trial entry