HIGHER INTAKE OF FRUITS AND VEGETABLES IN PREGNANCY IS ASSOCIATED WITH BIRTH SIZE

See-Ling Loy¹, M Marhazlina¹, Y Nor Azwany² and JM Hamid Jan¹

¹Nutrition Programme, School of Health Sciences, ²Community Medicine Department, School of Medical Sciences, Universiti Sains Malaysia, Kelantan, Malaysia

Abstract. Maternal nutrition has a programming effect on fetal growth. This cross-sectional study investigated the association between maternal micronutrient, fruit and vegetable intake with birth size. Nutrient and food intake were examined using a validated semi-quantitative food frequency questionnaire. One hundred twenty-one pregnant women at 28 to 38 weeks gestation aged 19-40 years, were recruited from the Universiti Sains Malaysia Hospital, Malaysia. Birth weight, length and head circumference were obtained from the medical records. Data were analyzed using multiple linear regression. Results indicate no significant association between any of the measured micronutrients and birth size. However, 2 of the 6 vegetable subgroups and those consumed fruit during pregnancy had children whose birth size was significantly associated with consumption. An increase of 10 g of leafy vegetables per day was associated with a 1.78 cm increase in head circumference (p=0.04), and tuber vegetable intake was associated with birth length (β=0.21, p=0.03) and head circumference (β=0.21, p=0.01). Fruit intake was associated with birth weight (β=0.19, p=0.04), birth length (β=0.20, p=0.04) and head circumference (β=0.19, p=0.03). The lack of association between maternal nutrient intake and fetal growth and the significant association between fruit and vegetable intake and birth size suggests the existence of other micronutrients and phytochemicals present in foods that play an important role in birth size. The types of nutrients and their roles in birth size warrant further investigation.

Keywords: maternal dietary intake, vegetables, fruits, pregnancy, birth size

INTRODUCTION

The “fetal origins” hypothesis proposes alterations in fetal nutrition or an adverse environment in utero can lead to a permanent physiological change in the fetus, predisposing to chronic disease in later life (Barker, 1994, 1995). This hypothesis has led to the renewed interest in nutrition during pregnancy and the assumption that improving maternal nutrition could improve fetal growth and subsequent health (Yajnik, 2006). Birth weight, birth length, head circumference, ponderal index and placental weight have been used as indicators of fetal growth to predict adult diseases (Godfrey and Barker, 2000, 2001; Barker, 2001, 2003).

Many studies have reported the effect of maternal nutrition on birth outcomes by focusing on single macro- or micronutrients, but with contradictory results.
Maternal Fruits and Vegetables Intake with Birth Size

(Langley-Evans and Langley-Evans, 2003; Lagiou et al, 2004; Moore et al, 2004; Andreasyan et al, 2007; Nagata et al, 2007; Abu-Saad and Fraser, 2010). Specific nutrient, intake of whole food components during pregnancy in relation to birth outcomes has been examined (Olsen et al, 1991; Petridou et al, 1998; Olsen et al, 2002; Mannion et al, 2006). To our knowledge, there have been only three studies which focused on maternal fruit and vegetable consumption and birth size (Rao et al, 2001; Mikkelsen et al, 2006; Ramon et al, 2009). Positive associations were found between vegetable intake and birth size in all three studies; the effect of fruit intake on birth size has only been reported in two studies which showed a positive association (Rao et al, 2001; Mikkelsen et al, 2006).

Birth size varies by ethnic group. According to Yadav (1983), Malaysian Chinese babies had the highest birth weight, followed by Malay babies and Indian babies. We focused on examining the birth size of Malay babies, since Malays are the major population in Malaysia especially in Kelantan state. To our knowledge, no study has been carried out in Malaysia to examine the association between maternal dietary intake in pregnancy and birth size. We investigated the effect of maternal diet on birth size among Malays. We focused on fruit and vegetable consumption and hypothesized micronutrients, vegetables and fruit intake during pregnancy would exert an impact on birth size.

MATERIALS AND METHODS

Study subjects

The pregnant women in their third trimester were identified through the antenatal clinic at the Universiti Sains Malaysia Hospital (HUSM), Kelantan, Malaysia. The Kelantan State is located in northeastern Peninsular Malaysia, where ethnic Malays comprise 95% of the population. Inclusion criteria were: 1) Malaysian citizenship and Malay ethnicity; 2) aged 19 - 40 years; 3) pregnant with an estimated gestational age of 28 to 38 weeks based on the last normal menstrual period or an early ultrasound scan; 4) and having the ability to give informed consent. One hundred seventy-seven women were recruited from November 2009 to March 2010. The study was approved by the Research Ethics Committee (Human) HUSM and written informed consent was obtained from each participant.

Data collection

Information regarding sociodemographic, medical and pregnancy history were obtained using a standardized questionnaire. Height was measured using a stadiometer (SECA, Germany) and weight was measured using a digital weighing scale (SECA, Germany). Pre-pregnancy weight was based on the mothers’ recall. A high correlation ($r=0.98$) between actual and recalled pre-pregnancy weight had been reported previously (Steven-Simon et al, 1986).

Birth weight, length, head circumference and gestational age at delivery were obtained from the medical records. Women who had multiple pregnancies, women with preexisting chronic diseases, such as diabetes mellitus, hypertension and heart disease, and those who did not give birth at HUSM were excluded from the analysis, leaving a total of 121 women. No women were excluded due to misreporting of energy intake, since the energy adjustment approach based on the Willet residual method (Willet, 1998) is more appropriate to handle misreporting and to assess diet-disease relationships (Poslusna et al, 2009).
Dietary assessment

A dietary assessment was carried out in face-to-face interviews by dieticians using a validated semi-quantitative food frequency questionnaire (FFQ). The FFQ has been validated against two 24-hour dietary recalls among pregnant mothers. The Spearman correlation coefficient and cross classification analysis were used to estimate validity. A reproducibility test was repeated 20-28 days apart. It was assessed using intraclass correlation (Table 1). The FFQ contained 82 food categories with an assigned standard portion size for each food category. Mothers were asked to recall their food intake during the preceding six months of pregnancy, followed by estimating the frequency of intake either daily, weekly or monthly, and the respective portion size. An Atlas of Food Exchanged & Portion sizes (Suzana et al, 2009) containing color pictures of common household measures was used to aid in identifying portion size. The energy and nutrient values for each food category were obtained from the Malaysian Nutrient Composition of Foods and USDA nutrient database using Nutritionist Pro™ software (Axxya Systems LLC, Stanfford, TX).

Statistical analysis

The nutrient and food intake distributions were described in median and inter-quartile ranges since all of them were positively skewed. Associations between maternal nutrient and food intake and birth outcomes were examined using multiple linear regression analyses. Maternal variables were included in the analyses if they were significantly associated with birth outcomes on univariate analysis or reported in previous studies (Moore et al, 2004; Andreasyan et al, 2007). These included social class based on maternal employment, monthly household income,
maternal height, weight at recruitment, pre-pregnancy weight, body mass index, gestational age at delivery, parity and infant sex. Nutrient and food intake were log-transformed to reduce the leverage of outliers and adjusted for total energy using the residual method described by Willet (1998). All statistical evaluations were computed using the Statistical Package for the Social Sciences (SPSS) version 18.0 (SPSS, Chicago, IL).

RESULTS

Table 2 shows the maternal and birth characteristics among 121 pairs of mothers and infants. Fifty-six mothers (32%) were dropped from the study due to multiple pregnancies or not giving birth at the HUSM. Pre-pregnancy body mass index showed 5.6% of women were underweight, 54.6% of women were normal weight, 9% of women were overweight and 13.9% of women were obese. Twenty-nine point eight percent of women were primiparous. None of the women smoked during pregnancy. The mean birth weight was normal and the majority (98%) delivered at full-term. Only 5% of babies had a low birth weight (<2,500 g). In general, boys had higher birth weights, birth lengths and head circumferences than girls, although the corresponding differences were not statistically significant.

Table 3 shows the estimated median daily intake of energy and nutrients in pregnancy. The main energy sources were carbohydrates (60%), followed by fat (24%) and protein (16%). On average, maternal energy and protein intake were...
Energy and nutrient intakes among pregnant Malay women.

<table>
<thead>
<tr>
<th>Nutrient intake</th>
<th>Median</th>
<th>Lower quartile</th>
<th>Upper quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kJ/d)</td>
<td>8,543.8</td>
<td>6,808.5</td>
<td>11,002.5</td>
</tr>
<tr>
<td>Protein (g/d)</td>
<td>83.9</td>
<td>64.3</td>
<td>108.7</td>
</tr>
<tr>
<td>Carbohydrate (g/d)</td>
<td>306.4</td>
<td>255.4</td>
<td>394.1</td>
</tr>
<tr>
<td>Fat (g/d)</td>
<td>54.6</td>
<td>42.8</td>
<td>72.6</td>
</tr>
<tr>
<td>Sodium (mg/d)</td>
<td>2,736.5</td>
<td>1,930.4</td>
<td>3,616.6</td>
</tr>
<tr>
<td>Potassium (mg/d)</td>
<td>1,648.1</td>
<td>1,224.1</td>
<td>2,218.6</td>
</tr>
<tr>
<td>Calcium (mg/d)</td>
<td>820.5</td>
<td>540.0</td>
<td>1,293.4</td>
</tr>
<tr>
<td>Iron (mg/d)</td>
<td>20.1</td>
<td>14.5</td>
<td>28.3</td>
</tr>
<tr>
<td>Phosphorus (mg/d)</td>
<td>997.5</td>
<td>757.8</td>
<td>1,334.4</td>
</tr>
<tr>
<td>Vitamin A, REa (µg/d)</td>
<td>959.0</td>
<td>608.5</td>
<td>1,642.4</td>
</tr>
<tr>
<td>Vitamin C (mg/d)</td>
<td>121.2</td>
<td>75.0</td>
<td>180.4</td>
</tr>
<tr>
<td>Thiamin (mg/d)</td>
<td>1.6</td>
<td>1.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Riboflavin (mg/d)</td>
<td>2.0</td>
<td>1.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Niacin (mg/d)</td>
<td>15.9</td>
<td>11.5</td>
<td>21.4</td>
</tr>
<tr>
<td>Dietary fiber (g/d)</td>
<td>7.0</td>
<td>4.2</td>
<td>9.9</td>
</tr>
</tbody>
</table>

a RE, retinol equivalents

Table 3

9,071.6 (2,929) kJ/d and 90.4 (41.1) g/d, respectively. These values are comparable to the Recommended Nutrient Intake (RNI) for Malaysian pregnant women (NCCFN, 2005). Vitamins A and C, micronutrients rich in vegetables and fruits had the mean values of 1,453.6 (1,354.4) µg and 145.1 (105.2) mg, respectively. Intake was higher than recommended according to the RNI (NCCFN, 2005). Regression analysis indicated no significant association between any of the measured macronutrients and birth size.

Table 4 shows the median daily intake of the vegetable subgroups and fruits consumed during pregnancy. Leafy vegetables were eaten more frequently than other vegetable subgroups. Overall, total fruit and vegetable intake was inadequate using the Malaysian Food Pyramid recommendations (NCCFN, 2010). A multiple regression model showed leafy vegetables, tuber vegetables and fruits were significantly associated with birth size (Table 5). An increase of 10 g of leafy vegetables was associated with a 1.78 cm increase in head circumference at birth ($p=0.04$). Tuber vegetable intake was positively associated with birth length ($\beta=0.21$, $p=0.03$) and head circumference ($\beta=0.21$, $p=0.01$). Fruit intake was positively associated with birth weight ($\beta=0.19$, $p=0.04$), birth length ($\beta=0.20$, $p=0.04$) and head circumference ($\beta=0.19$, $p=0.03$).

DISCUSSION

The majority of pregnant women were normal or overweight before conception, indicating undernutrition is not common in this population. It also manifests the growing problem of overweight and obesity in the Malaysian adult population, especially among women (Institute of Public Health, 2008).

In this study, energy, macronutrients
Maternal Fruits and Vegetables Intake with Birth Size

Intake of fruits and vegetables among pregnant Malay women.

<table>
<thead>
<tr>
<th>Food intake (g/d)</th>
<th>Median</th>
<th>Lower quartile</th>
<th>Upper quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leafy vegetables&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.4</td>
<td>9.2</td>
<td>29.7</td>
</tr>
<tr>
<td>Cruciferous vegetables&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.1</td>
<td>3.6</td>
<td>14.3</td>
</tr>
<tr>
<td>Legume vegetables&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.3</td>
<td>0</td>
<td>6.0</td>
</tr>
<tr>
<td>Tuber vegetables&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.0</td>
<td>0</td>
<td>12.6</td>
</tr>
<tr>
<td>Salad “ulam”&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.7</td>
<td>0</td>
<td>5.6</td>
</tr>
<tr>
<td>Other vegetables&lt;sup&gt;f&lt;/sup&gt;</td>
<td>14.7</td>
<td>3.7</td>
<td>29.4</td>
</tr>
<tr>
<td>Fruits&lt;sup&gt;g&lt;/sup&gt;</td>
<td>147.0</td>
<td>88.0</td>
<td>272.2</td>
</tr>
</tbody>
</table>

<sup>a</sup>Included mustard leaves, swamp cabbage, kale, spinach, sweet potato shoots, fern shoots
<sup>b</sup>Included common cabbage and cauliflower
<sup>c</sup>Included string beans and four-angled beans
<sup>d</sup>Included potatoes, carrots and sweet potatoes
<sup>e</sup>Included Indian Pennywort and “Ulam raja”
<sup>f</sup>Included cucumbers, gourds and tomatoes
<sup>g</sup>Included oranges, apples, bananas, pears, papayas, watermelons, honeydew melons, pineapples, mangos, guavas, water apples, grapes, duku, rambutans, durians, mangosteens and jackfruits.

Intake of fruits and vegetables with birth outcomes among pregnant Malay women<sup>a</sup>.

<table>
<thead>
<tr>
<th>Food intake (g)</th>
<th>Birth weight</th>
<th>Birth length</th>
<th>Head circumference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>p</td>
<td>β</td>
</tr>
<tr>
<td>Leafy vegetables</td>
<td>-0.12</td>
<td>0.20</td>
<td>0.18</td>
</tr>
<tr>
<td>Cruciferous vegetables</td>
<td>-0.12</td>
<td>0.22</td>
<td>0.06</td>
</tr>
<tr>
<td>Legumes</td>
<td>0.12</td>
<td>0.22</td>
<td>-0.04</td>
</tr>
<tr>
<td>Tuber vegetables</td>
<td>0.06</td>
<td>0.53</td>
<td>0.21</td>
</tr>
<tr>
<td>Raw vegetables “ulam”</td>
<td>0.002</td>
<td>0.98</td>
<td>-0.08</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>0.03</td>
<td>0.74</td>
<td>-0.05</td>
</tr>
<tr>
<td>Fruits</td>
<td>0.19</td>
<td>0.04b</td>
<td>0.20</td>
</tr>
</tbody>
</table>

<sup>a</sup>Adjusted for social class based on maternal employment, monthly household income, maternal height, weight at recruitment, pre-pregnancy weight, body mass index, gestational age at delivery, parity and infant sex. Food intake adjusted for total energy.
<sup>b</sup>Significant at 95% confidence interval p<0.05

and micronutrients were not significantly associated with birth parameters. Similar findings were seen in studies among pregnant women in southern England (Mathews et al, 1999) and the United States (Lagiou et al, 2004). According to Yajnik (2006), maternal macronutrient intake was not a strong factor in determining birth size. Both vitamins A and C are common in fruits and vegetables, but were not associated with birth size. Other studies indicated maternal energy (Susser, 1991),
protein (Andreasyan et al, 2007), carbohydrate (Moore et al, 2004), fat (Kanade et al, 2008) and micronutrient intake (Osirin et al, 2005; Watson and McDonald, 2010) were associated with birth size in poor countries where nutrient deficiencies are common (Christian, 2003; Abu-Saad and Fraser, 2010). It has been argued the impact of maternal nutrients upon birth outcomes is greater in less affluent countries (Doyle et al, 1992). An association will only emerge when a large deviation from normal nutrient intake is found in a population. This explains the limited impact of maternal nutrients on birth size seen in the present study in Malaysia, a prosperous thriving middle-income nation. A non-significant association may also be partly due to the dilution effect of other non-nutritional variables not included in the analysis.

Six vegetable subgroups were examined in the present study. These were leafy vegetables, cruciferous vegetables, legume vegetables, tuber vegetables, salad "ulam" and other vegetables. "Ulam" is a traditional salad recognised as a popular main dish in traditional Malay villages. The positive association between vegetable intake and birth size was in line with some studies (Rao et al, 2001; Mikkelsen et al, 2006; Ramon et al, 2009), but not with one earlier study by Petridou et al (1998). A small increase in birth weight in our study was only seen by the consumption of tuber vegetables, but not green leafy vegetables, as found in other studies (Rao et al, 2001; Mikkelsen et al, 2006; Ramon et al, 2009). A possible explanation is the small amount of green leafy vegetables consumed did not play a significant role in birth size. When analysing the relationship between consumption of all vegetable subgroups with birth size, no significant associations were found (data not shown). This indicates the important role of specific types of vegetables.

Increasing consumption of fruits was associated with an increase in all birth size parameters. Our findings agree with previous studies that fruit intake increased birth weight by 10.7 g per quintile in a Danish study (Mikkelsen et al, 2006) and 4.3 g per category of consumption in an Indian study (Rao et al, 2001). Studies in Greece (Petridou et al, 1998) and Spain (Ramon et al, 2009) found no association between fruit intake and birth size. It is inappropriate to compare the findings of studies assessing fruits intake with birth size, especially among Asians. Fruits consumed by western populations contribute different types of nutrients and have different effects on birth size. Differences in study design and statistical analysis may also lead to differences in findings.

Fruits and vegetables are a rich source of antioxidants and phytochemicals. The differences between fruits and vegetable of growth reflect different micronutrients and phytochemicals in relation to fetal growth. The lack of association between examined micronutrients and birth size, but the significant associations between fruit and vegetable intake and birth size, suggest other unmeasured nutrients in fruits and vegetables contribute to these differences. Several studies have investigated antioxidant intake on birth size, with inconsistent results (Boer et al, 2009). The weak association between intake of fruits and vegetables and birth size may be partly due to better nutritional status in the studied population. However, we believe a stronger association will be observed for the same food groups and birth size when studying undernourished populations as was found in a previous study (Kanade et al, 2008).

Strengths and limitations are present
in the present study. The major strength of this study was the inclusion of different vegetable subgroups in the analysis. It provides a clearer picture of the beneficial roles of specific types of vegetables in promoting fetal growth. Food-based analysis provides a clearer message in relation to dietary recommendations, which facilitates later intervention programs. Supplements, such as vitamins, minerals (Alwan et al, 2010) and herbal medicines (Azriani et al, 2009) that are commonly taken during pregnancy, were not analysed in this study since our main purpose was to investigate the effect of natural food intake on birth size. The high drop out rate of mothers led to a small sample size in our study. However, this did not bias the results, since there were no significant differences in dietary intake between the included and excluded women (data not shown). The small sample size causes difficulty in generalizing our results. However, the significant associations between fruit and vegetable consumption and birth size highlight the importance of those foods for improving birth size. This serves as a reference to further studies of the effect of maternal dietary patterns on birth size, as shown by a study in Denmark (Knudsen et al, 2008). Participation bias may attenuate findings, where those who took part in the study were more likely to have a healthier lifestyle and better nutritional status, which could impact the reported dietary intake and birth size. However, dietary that obtained prospectively before knowing the birth weight helps to reduce information bias. Misreporting may occur among mothers who deliver low birth weight or high birth weight infants when dietary data are obtained after pregnancy.

Increasing consumption of fruits and vegetables is associated with better birth size. The present findings suggest consumption of fruits and vegetables plays a beneficial role in improving birth size and subsequent health outcomes. However, the contribution of unmeasured micronutrients and phytochemicals present in fruits and vegetables and their roles in determining birth size warrant further investigation.

ACKNOWLEDGEMENTS

We are grateful to the research team, hospital staff and women subjects for their cooperation and support. We would like to acknowledge the University Sains Malaysia (USM) for funding the study via a USM Research University Grant (PPSK/1001/811087). We would also like to thank the USM fellowship for funding See-Ling Loy and the Ministry of Higher Education Malaysia and the Universiti of Zainal Abidin for funding M Marhazlina.

REFERENCES


Maternal Fruits and Vegetables Intake with Birth Size


