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Reduced maternal calcium intake through nutrition and supplementation is associated with adverse conditions for both the women and their infants in a Chinese population

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Abstract

Effective nutritional guidelines for pregnant women in China are lacking. The aim of this study was to investigate the effect of dietary nutrition on the health condition of pregnant women and infants in China.

In total, 331 pregnant women who had prenatal examinations were included in this study. Data, including dietary nutrition questionnaires, the weight, height, age, and health condition of the pregnant women as well as the health condition of the infants, were recorded.

The average intake of milk, poultry and meat, fish and prawns, eggs, and bean products were 297.28 ± 129.67 mL/day, 123.34 ± 52.04 g/day, 157.31 ± 70.04 g/day, 67.34 ± 45.28 g/day, and 1.21 ± 0.62 per day, respectively. Among the 331 pregnant women, the intake rates of supplemental calcium and VD were 86.7% and 69.8%, respectively. The intake of milk, bean products, and meats was obviously lower (all $P < .05$) in the pregnant women with systremma compared to those without it. In addition, the body weight before and after delivery was higher (all $P < .05$) in the pregnant women with systremma. The calcium intake of the pregnant women and the infants' BMD were remarkably lower in the infants with pillow baldness or a wider anterior fontanelle ($P < .01$) compared to those without the features.

The intake of milk, poultry and meat, fish and prawns, eggs, and bean products by pregnant women should be monitored, and in particular, the proper intake of milk, bean products, and meats, as well as calcium supplements, might decrease the occurrence of systremma in pregnant women and reduce the rate pillow baldness and a wider anterior fontanelle in infants.

Abbreviations: BMD = bone mineral density, SD = standard deviation, VC = vitamin C, VD = vitamin D.

Keywords: calcium supplements, infant health, maternal dietary nutrition, pregnancy, vitamin D

1. Introduction

Pregnant women undergo great physiological and metabolic changes that require specific maternal nutritional requirements, which play an important role in maternal and fetal development as well as in postpartum lactation.[1,2] The maternal nutritional status is closely associated with the child's health.[3] The relationship between maternal nutrition and fetal health is complex and can be affected by various factors, including biological, demographic and socioeconomic factors, and maternal health and adequate nutrition during prepregnancy, pregnancy, and lactation are beneficial to improving fetal outcome and health.[3] Therefore, a better understanding of maternal nutrition during pregnancy is necessary for infant health.

Experimental human and animal studies demonstrate the importance of the maternal nutritional status on fetal development and birth outcomes.[4,5] In addition, a previous study reviewed the association of birth outcomes with maternal nutritional requirements during pregnancy, such as fatty acids, protein, folate, vitamin C (VC), VD, iron, calcium, magnesium, and zinc, and revealed that an adequate maternal nutrition reduces the risk of adverse birth outcomes.[3] Usually the maternal nutritional requirements are provided through the consumption of milk, poultry and meat, fish and prawns, eggs, and bean products, suggesting the importance of the maternal dietary nutrition on infant health.[6,7] Several studies report that certain aspects of the maternal diet, such as the intake of milk, meat, and seafood, improve both the maternal and infant health.[8–11] Most of these studies were conducted in the United States and Europe, only a few studies have investigated the effect of maternal dietary nutrition on both maternal and infant health in China.

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A recent study reported that pregnant women in developing countries had an inadequate micronutrient intake, had a predominantly plant-based diet and had imbalanced macronutrients.[12] In particular, a large study investigating the nutrition and health status of pregnant women in China, covering 8 provinces, revealed a high rate of sural spasm during pregnancy, and a calcium deficiency seemed to be the leading cause of this occurrence.[13] In addition, VD deficiency during pregnancy and early childhood is linked to a number of health problem in both the mother and the child,[14] and a recent study demonstrated a VD deficiency or insufficiency in newborns in Shanghai, China.[15] There is a clear need for more studies relating maternal nutrition to infant health in China in order to provide better guidelines for pregnant Chinese women.

In the present study, dietary nutrition questionnaires from 331 pregnant women as well as the physical condition and bone mineral density (BMD) of the pregnant women and the infants were collected in order to investigate the effect of dietary nutrition on the health condition of the pregnant women and infants. These findings might contribute to the development of pregnancy-specific dietary guidelines in China.

2. Materials and Methods

2.1. Subjects

This study was approved by the Ethics Committee of Beijing Friendship Hospital, Capital Medical University. Pregnant women who had prenatal examinations in our hospital between January 2008 and December 2011 were enrolled in this study. The inclusion criteria were as follows: the pregnant women were asked to complete dietary nutrition questionnaires at 8 to 9 months of gestational age, which included their milk, poultry and meat, fish and prawns, eggs, bean products, calcium, and VD intakes and the pregnant women had no disease history, family history, and diseases influencing nutrition or bone metabolism. Pregnant women who had twins, multiple births, or premature infants were excluded from this study. As a result, a total of 331 pregnant women (aged 17–43 years) were included in this study. The pregnant women were followed up 2 to 3 months postpartum.

2.2. Data collections

The dietary nutrition questionnaires of all of the pregnant women were collected. Data, including the weight, height, age, and health condition of the pregnant women as well as the health condition of the infants, were recorded. The BMD was assessed in the puerpera women and in the infants 2 months postpartum using an ultrasonic bone analyzer (BMD-1000, Aonuo Pharmaceutical Co. Ltd, Baoding, China).

2.3. Statistical analysis

The statistical analyses were performed using 17.0 SPSS software (Chicago, IL). The continuous variables are expressed as the mean ± standard deviation (SD) and were analyzed by a *t* test and a 1-way analysis of variance. The categorical variables are represented as percentages. *P* values of less than .05 were considered statistically significant.

3. Results

3.1. Physical and dietary nutrition characteristics of the pregnant women

The average age and height of all of the pregnant women were 28.79 ± 3.48 years and 162.02 ± 5.04 cm, respectively. The average body weight of the pregnant women before pregnancy was 57.38 ± 4.74 kg, and before delivery, it was 73.31 ± 10.19 kg, $P < .05$). Thus, on average, the women gained approximately 16 kg during pregnancy. The average intake of milk, poultry and meat, fish and prawns, eggs, and bean products was 297.28 ± 129.67 mL/day, 123.34 ± 52.04 g/day, 157.31 ± 70.04 g/day, 67.34 ± 45.28 g/day and 1.21 ± 0.62 per day, respectively. Among the 331 pregnant women, the intake rates of calcium and VD were 86.7% and 69.8%, respectively.

3.2. The relationship between the incidence of systremma and the dietary nutrition of the pregnant women

During the third trimester, 54.7% of the pregnant women experienced systremma. The intake of milk, bean products, and meats was lower in the women with systremma compared to those who did not experience systremma (290.61 ± 121.74 vs 305.33 ± 138.62, 118.1 ± 47.2 vs 129.8 ± 56.9, and 423.18 ± 171.64 vs 408.65 ± 92.67, respectively, all $P < .05$). In addition, the weight of the pregnant women both before and after delivery was higher in the pregnant women with systremma compared those without (74.5 ± 10.9 vs 71.9 ± 9.0 kg before and 65.12 ± 11.56 vs 63.53 ± 9.51 kg after, respectively, all $P < .05$) (Table 1). There was no significant difference in the BMD values of the mothers and infants between the pregnant women with and without systremma (Table 1).

3.3. The relationship between pillow baldness and the anterior fontanelle size of the infants and the dietary nutrition of the pregnant women

The infants were born at an average gestational age of 39.3 ± 1.23 weeks. The average height and body weight of the infants were 49.89 ± 1.44 cm and 3.39 ± 0.46 kg, respectively. The intake of

Table 1

The dietary nutrition and bone mineral density in pregnant women with and without systremma (mean ± SD).

	Pregnant women with systremma (n)	Pregnant women without systremma (n)	*P*
Milk uptake, mL	290.61 ± 121.74 (181)	305.33 ± 138.62 (150)	<.05
Bean products uptake, g	118.1 ± 47.2 (181)	129.8 ± 56.9 (150)	<.01
Meats uptake, g	423.18 ± 171.64 (181)	408.65 ± 92.67 (150)	<.05
Weight before delivery, kg	74.5 ± 10.9 (181)	65.12 ± 11.56 (150)	<.05
Weight after delivery, kg	71.9 ± 9.0 (181)	63.53 ± 9.51 (150)	<.05
Mother's BMD	3117.86 ± 751.97 (111)	3106.06 ± 767.82 (69)	NS
Infant's BMD	2669.86 ± 298.23 (111)	2701.67 ± 307.19 (69)	NS

BMD = bone mineral density, NS = not significant, SD = standard deviation.

Table 2

The calcium uptake and bone mineral density in infants with and without pillow baldness (mean ± SD).

	Infants with pillow baldness (n)	Infants without pillow baldness (n)	P
Calcium uptake, g	4.16 ± 2.45 (201)	4.63 ± 2.34 (108)	<.01
Mothers' body weight, kg	66.38 ± 11.55 (201)	60.77 ± 8.56 (108)	<.01
Infants' BMD	2589.35 ± 315.77 (195)	2857.52 ± 169.19 (105)	<.01
Infants' body weight, kg	6.25 ± 0.83 (195)	5.36 ± 0.64 (105)	<.01

BMD = bone mineral density, SD = standard deviation.

calcium in the pregnant women during pregnancy as well as the infants' BMD values were remarkably lower in the infants with pillow baldness compared with the infants without pillow baldness (4.16 ± 2.45 vs 4.63 ± 2.34 and 2589.35 ± 315.77 vs 2857.52 ± 169.19, respectively, $P < .01$, Table 2). While the weight of the mothers and infants at 2 months postpartum were significantly higher for the infants with pillow baldness (66.38 ± 11.55 vs 60.77 ± 8.56 kg in the mothers and 6.25 ± 0.83 vs 5.36 ± 0.64 kg in the infants, all $P < .01$, Table 2). Moreover, the size of the anterior fontanelle of the infants was smaller when the calcium intake of the pregnant women and the infants' BMD were higher ($P < .01$, Table 3).

4. Discussion

Maternal nutrition is related to the normal growth of a fetus. Poor or excess maternal nutrition might influence the brain development of an infant, leading to embryonic malformation and an increased incidence of birth defects.[9] According to the Dietary Guidelines for Chinese Residents (2016),[16] the average intake of milk, poultry and meat, fish and prawns, eggs, and bean products of pregnant women during the second and third trimester are up to par. However, detailed studies on whether these guidelines are good enough to ward off adverse effects in both the pregnant woman and her child remain unclear.

When considering the nutritional requirements during pregnancy, calcium intake is especially important because if the maternal calcium stores are depleted, maternal bone health can be adversely affected, resulting in a lower BMD and an increased rate of bone resorption. The third trimester is when it has the greatest consequence.[17] The body does not make calcium, and thus, calcium must be consumed through the dietary intake, after which it is sent to the skeletal system 98% of it is stored.[18] During pregnancy, fetal nutritional needs place great demand on the maternal nutritional needs in order to not deplete the maternal skeletal calcium storage.[17] In our study, we found that calcium intake, either through diet or a supplement was adequate based on the guidelines mentioned above, but when we examined our cohort of patients in more detail we found that the calcium intake actually could be divided into high and low groups and these were associated with certain conditions in both the women and the infants.

Systremma is known as a leg cramp induced by abnormal neuromuscular excitability and, it is related to fatigue, cold, hypocalcemia, and blocked blood flow.[19] Leg cramps commonly occur during pregnancy.[20] The incidence of systremma in this study was 54.7% during the third trimester, and the occurrence of systremma was associated with a reduced intake of milk, bean products, and meats as well as a higher weight before and after delivery. The maternal nutritional requirement for calcium increases during the second and third trimester,[18] and a lack of calcium might lead to the occurrence of systremma due to the increased neuromuscular excitability in pregnant women.[21] Notably, the intake of milk, bean products, and meats increases the amount of calcium the women receive,[22] which thereby reduces the occurrence of systremma. In addition, heavier pregnant women have a greater requirement for calcium and have an increased level of burden to their legs and muscular tension, which might also be a cause of systremma. However, systremma was not related to the BMD of the mothers and infants in this study, which might be due to the small sample size.

The bone mineral content plays a vital role in maternal health and fetal skeletal development, and BMD is an important symbol of bone quality.[23] Calcium supplementation increases the bone mineral content and prevents osteoporosis during pregnancy,[24] and VD is also reported to be associated with calcium metabolism and bone health.[25] A number of studies demonstrate significant decreases in bone mineral indicators in pregnancy, and the greatest changes occur during the third trimester when the maternal–fetal calcium transfer is the highest.[26–28] The BMD value is used as indicator of bone health and measures the density of the bone in grams per cubic centimeter. During pregnancy, the total BMD values have been shown to be decrease by up to 3.6%.[29] In fact the rate of bone loss during pregnancy is greater than the annual rate of loss in women after menopause.[30] Thus, it is very important that pregnant women intake adequate calcium levels.

Pregnant women need extra calcium to protect against the loss that occurs during the maternal–fetal transfer and to also ensure that the infant is gaining enough calcium as it develops in utero. It was well-known that the occurrence of pillow baldness and an increased size of the anterior fontanelle are both associated with inadequate calcium supplements.[31,32] In the present study, we revealed that when there were increased levels of the intake of

Table 3

The calcium uptake of pregnant women and infants' BMD in infants with different size of anterior fontanelle (mean ± SD).

	Anterior fontanelle with 1 cm (n = 89)	Anterior fontanelle with 2 cm (n = 84)	Anterior fontanelle with 3 cm (n = 84)	P
Calcium uptake, g	4.89 ± 2.09	4.26 ± 2.39	3.85 ± 2.56	<.01
Infants' BMD	2792.09 ± 233.22	2656.69 ± 298.67	2606.14 ± 341.09	<.01

BMD = bone mineral density, SD = standard deviation.

calcium supplements during pregnancy and an elevated BMD in the infants, these were associated with a remarkable decrease in the occurrence of pillow baldness and a wider anterior fontanelle in the infants. These results suggested that the proper intake of calcium is indeed necessary for infant health.

5. Conclusions

According to the current Dietary Guidelines for Chinese Residents (2016),[13] the intake of milk, poultry and meat, fish and prawns, eggs, and bean products by the pregnant women in this study was reasonable. However, when we further studied this group of pregnant women, we found that they could be divided by the occurrence of systremma, and this was associated with a reduced intake of milk, bean products, and meats as well as a higher weight of the pregnant women. These products all contribute to the overall intake of calcium. Furthermore, for the women with an increased intake of calcium supplements and the infants with an elevated BMD, there was a decreased occurrence of pillow baldness and a wider anterior fontanelle in the infants. Together these findings suggest that adequate calcium intake by pregnant women is important for their health and for the health of their infants. In addition, this also suggests that the current guidelines should be refined to better assess calcium intake for pregnant Chinese women.

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