Original Article

Effect of daily milk supplementation on serum and umbilical cord blood folic acid concentrations in pregnant Han and Mongolian women and birth characteristics in China

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Many studies have demonstrated the efficacy of folic acid (FA) supplementation in prevention of neural tube defects (NTDs), although the extent of NTDs varies among individuals of different races and ethnic origin. China is a multi-ethnic country with no standard practice for FA-fortified food. Milk is consumed by women, but little is known about the effects of milk on folate concentration in maternal blood and neonatal umbilical cord blood in Han and Mongolian women after stopping taking the supplement for a month and five month, respectively. The objective of this study was to determine whether only daily consumption of liquid milk can increase the blood folate concentration in pregnant women and whether there are differences in blood folate concentrations between Han and Mongolian women after cessation of FA supplementation. Of the 4052 women enrolled in the parallel group design study. Three thousand five hundred and twenty-six women had confirmed pregnancies and were randomized to receive liquid milk or not until delivery. Women who consumed the liquid milk had significantly increased serum folate concentrations at 16 and 32 weeks of gestation as well as cord blood at birth compared to control groups in both ethnic groups. Infants born to women drinking milk also had better the term birth weight and height, which may be related to the increased concentration of folate. In conclusion, daily consumption of milk can increase the serum folate concentration in pregnant Han and Mongolian women in China (differences in the efficacy of FA and milk supplementation) and may enhance birth outcomes.

Key Words: folic acid, milk, neonatal birth weight, birth defects, umbilical cord blood

INTRODUCTION

Periconceptional folic acid (FA) supplementation in women has been established to reduce the risk of neural tube defects (NTDs), congenital heart defects, preeclampsia, arsenicosis.[1-3] Therefore, FA supplementation and food fortification have been broadly implemented in America, New Zealand, Chile and many other countries in the past decade.[4-10] For instance, Fortification of milk is one of the strategies to increase FA consumption in New Zealand. However, FA fortification is not widely used in many food products such as grain, wheat, milk and cereal in China.

Though we have obtained certain achievement in preventing NTDs by supplementing with folic acid tables, series of problems still exist. China is a multi-ethnic population country and the development of main area is very lopsided. Many women do not realize the importance of supplement with folic acid in China owing to its inadequate publicity. The prevalence rate of NTDs varies dramatically between the north and the south in China as well as between urban and rural areas. In general, the rate of NTDs in North or rural areas is higher than that of in the South or the urban.[11-13] Besides, periconceptional use of folic acid was significantly increased among

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women with more than high school education, women with a history of birth-defect affected pregnancy in Shan Xi province North of China in where has one of the highest birth prevalence of NTDs in the world.[14] Although the Chinese Ministry of Health began to carry out folic acid supplementation among women of childbearing age to prevent NTDs in 1993, the birth prevalence of NTDs remains high in some provinces of the country. There are not any fortified foods with folic acid in China. Generally, women who are pregnant or are planning a pregnancy are recommended to take a daily oral supplement tablet of 400 μg of FA, as a 46-79% reduction in the risk of NTD has been observed in women taking this regimen in China.[15]

Some studies have also shown that fortified milk can increase serum folate level and lower homocysteine concentrations,[16] as well as enhance folate bioavailability compared to diet with other foods.[17] The time when detecting the concentration of folate was just stopped supplementing with milk in all these studies. However, little is known about the effect of only milk on folate concentration in the blood and in the umbilical cord blood when consumed by women at different stages of pregnancy, including 16 and 32 weeks of gestation (ie, after stopping taking the supplement for a month and five month, respectively). In addition, relationships between the birth weight and height of neonates, milk supplementation and concentration of folate are unclear in the Han and Mongolian women in China. Although FA taken prior to conception and during early pregnancy reduces the risk of NTDs in the population as a whole, different effects have been observed among people of various races and ethnic origins. Williams et al reported differences in the efficacy of FA supplementation in preventing NTDs in Hispanic, non-Hispanic white and non-Hispanic black newborns.[18] The similar results were observed in an Australian population. NTDs have declined by about 30% in the non-Aboriginal population, but no change has been seen in the Aboriginal population after voluntarily taking FA-fortified food.[19] Unfortunately, no trial with a large sample size on FA supplementation or fortification has been conducted in multi-ethnic populations in China.

Thus, the objective of this study was to assess the benefits of consuming liquid milk at periconception when had stopping supplementing with FA on the serum folate level in women and neonates from different races (Han and Mongolian) in China.

METHODS

Subject recruitment

The "Project of a Glass of Milk" was carried out and studied in women of childbearing age (19-43 years old) in Tongliao city in the Nei Monggol Autonomous Region of North China. All volunteers (n=4052, Mongolian, 2122; Han, 1930) from four districts of Tongliao city came to the rural and the urban maternal and child health centre for prenatal consultations and wanted to take part in the free trial providing by government. Women who consumed vitamins or folic acid in the previous three months were excluded. The women who had a history of NTD or other diseases were also excluded. The women have tobacco, gambling and any other bad habits were also excluded. The women who were not the Han and Mongolia of local resident were excluded. The Human Ethics Committee of the Peking union medical college approved the study (ethics approval number NRIFP 200903) and all women gave written and informed consent to participate.

Intervention and groups

This was a parallel group design study. The participant flow chart of design was shown in Figure 1. The women were weighed and had their height, blood pressure measured. All these women were instructed to complete a demographic and lifestyle questionnaire and were carefully informed verbally and in writing on how to prepare and take FA and milk. They also were instructed to not take other vitamins, milk and other sources of FA. These

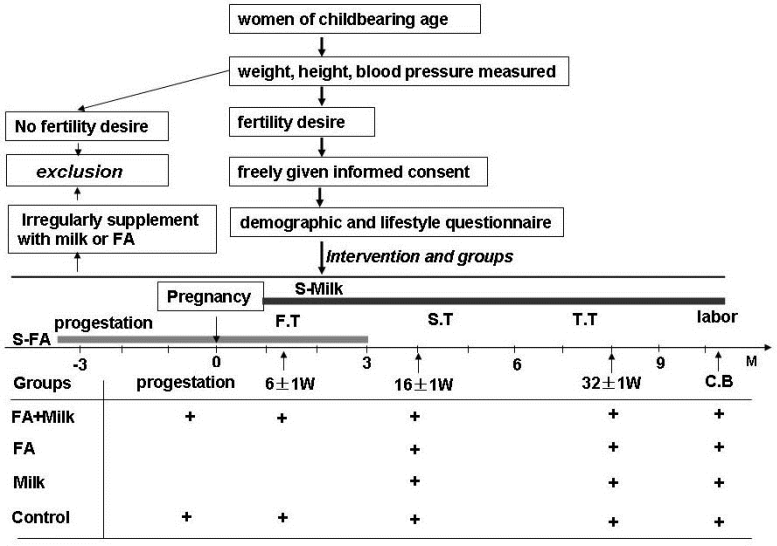

Figure 1. The participant flow chart of design. S-Milk: supplement with milk; S-FA: supplement with folic acid; C.B: cord blood; F.T: the first trimester; S.T: the second trimester; T.T: the third trimester; Control group: neither supplement with milk nor folic acid; "+": the time points of FA assay; S-FA: supplement with folic acid from the first three months before pregnancy and after three months becoming pregnant; S-Milk: supplement with milk was only pregnancy confirmed.

women who became pregnant while participating in the trial were told to inform the trial organizer in order to begin milk supplementation immediately if required according to the study design. The levels of folate in milk (89 samples) were tested by Chinese dairy enterprises. All the samples contain folate, which ranged in concentration from 1.68 to 5.69 μg/100 mL. The average level of folate in the provided milk was 3.79 μg/100 mL.

These participants were divided first into two ethnic groups, Han and Mongolian, each of which were further divided into four groups according to their assigned supplement regimen. Group 1 (FA+milk) took FA tablets before pregnancy and drank liquid milk after confirming pregnancy. Group 2 (milk) did not take FA tablets before pregnancy but did drink liquid milk after confirming pregnancy. Group 3 (FA) took FA tablets before pregnancy without drinking milk throughout the trial. Group 4 (control) did not take FA tablets before pregnancy nor drank milk throughout the trial. Women with confirmed pregnancies (5-7 weeks) were instructed to drink liquid milk daily until parturition. Medical methods such as early pregnant test paper, B-ultrasonography confirmed pregnancy. Gestational age (16 weeks and 32 weeks) were defined on the basis of the last menstrual date and ultrasound examination.

Fasting venous blood samples were collected at AM 8:00-10:00. Cord blood was collected at birth. Blood from non-pregnant women and cord blood samples served as controls. Blood was drawn from each participant into tubes containing EDTA. The whole blood samples were diluted 10-fold in 1% ascorbic acid to protect the FA from oxidation. All these blood samples were stored at -20℃ on the scene, and then were put together to a medical refrigerator at -70℃ until to measure. Plasma folate and whole blood folate concentrations were determined by a radioimmunoassay (I125) in Peking union lawke centre (CAP accreditation, NGSP standard, Certification by the Ministry of Health) for clinical trial laboratory testing. All blood samples were measured according to instructions of Kits (Lot: 20090801). The intraassay CV for serum folate was 5.0%; the inter-assay CV for serum folate was 8.2%. The SD was 0.17-0.77. Beside，the data of term birth (40±2W) outcomes including body length and weight and Apgar score were testified by Obstetrician/Gynecologist. Folate deficiency was defined as having a serum concentration of less than 6.8 nmol/L.

Milk and folic acid

Ultra high temperature treated liquid milk (UHT milk, 243 mL/container), was provided by Inner Mongolia Yili Industrial Group Co., Ltd. (Huhhot, Inner Mongolia, China). FA tablets, provided by the Scrianen Pharmaceutical Co., Ltd (Beijing, China), were taken in the first three months before pregnancy and after three months becoming pregnant. Participants were instructed to drink a container of the liquid milk (243 mL) in the morning. As recommended by, participants were instructed to take a 400 μg FA tablet once a day. The free milk was periodically sent to the home of participants confirmed pregnancy by organizers received professional training. The organizers periodically recorded about drinking milk including stop or miss drinking or allergies.

Statistical analysis

Statistical analyses were performed using Version 15 of SPSS for Macintosh software (SPSS Inc, Chicago). Quantitative data are expressed as mean ± SD. The individual effects of milk, folic acid supplementation and ethnicity and their interactions on the concentration of serum folate concentration are explored by using factor analysis. Student-t test is used for the comparison of birth weight, height and developmental index between those with milk supplementation or those not. Categorical data is analyzed by chi-square test. $p<0.05$ was regarded as significant.

RESULTS

General characteristics of the study population

From December 2008 to May 2010, 4052 women were interviewed. Of the 3526 women had confirmed pregnancies and were randomized to receive liquid milk or not until delivery. Women gave up halfway for the following reasons; anaemia (N=1), gastrointestinal disturbances (N=5), dislike of the milk (N=9), other reasons (N=12). Almost of participants were non-smoking. The distribution for other demographic and obstetric characteristics is shown in Table 1.

Supplementation can increase serum folate concentrations in both Han and Mongolian ethnic groups

Serum folate concentrations at baseline were similar with no significant difference between the Han and Mongolian women without FA supplementation. However, serum folate concentrations increased after receiving FA in both ethnic groups, compared with those without FA supple-

Table 1. Demographic characteristics (N=4052)

Characteristics of mothers	Mongolian (n=2122)		Han (n=1930)	
	n	%	n	%
Age (years)				
19～25	900	42.4	778	40.3
25～30	844	39.8	804	41.7
30～43	378	17.8	348	18.0
Education levels (years)				
≤7	566	26.7	473	24.5
7～9	1069	50.4	892	46.2
≥10	487	30.0	565	29.3
Gravidity (n)				
0	257	12.1	296	15.3
1	1723	81.2	1549	80.3
2	142	6.7	85	4.4
Offspring (n)				
0	1980	93.3	1845	95.6
1	142	6.7	85	4.4
Height (cm)	161 (150-177)		160 (149-178)	
Weight (kg)				
Non-pregnant	57.3 (43.5-80.0)		58.0 (45.0-78.5)	
F.T 6±1w	58.5 (45.5-81.5)		59.4 (47.0-81.0)	
S.T 16±1w	61.7 (49.5-84.5)		62.5 (50.5-83.5)	
T.T 32±1w	69.6 (57.5-86.0)		70.1 (59.5-93.0)	
before labour	73.9 (61.5-98.5)		74.7 (63.0-97.5)	
Non-pregnant	22.7 (18.5-26.9)		22.6 (18.5-26.9)	

F.T: the first trimester; S.T: the second trimester; T.T: the third trimester.

mentation. The folate concentrations in serum of Han women were 30.2% (23.2 nmol/L vs 17.8 nmol/L, $p<0.01$) and 34.6% (24.6 nmol/L vs 18.3 nmol/L, $p<0.01$) higher than those in Mongolian women ($p<0.01$) after supplementation with FA in the first the trimester and pre-pregnancy periods, respectively (see Table 2).

Drinking milk can significantly increase concentrations of blood folate in both Han and Mongolian ethnic groups

Serum folate concentrations were measured at 16 and 32 weeks of gestation (stopping taking the supplement for a month and five month, respectively) in pregnant women with or without daily milk supplementation, and umbilical cord blood samples at parturition were also evaluated. The results showed that in the pregnant women who drank milk daily, regardless of whether or not they were taking FA supplements, serum folate concentrations were higher at 16 and 32 weeks of gestation and in umbilical cord blood samples at delivery ($p<0.01$) than in those who did not drink milk in the two ethnic groups (see Table 3). However, there was no statistically difference in the serum folate concentration between the Han and Mongolian women with only milk supplementation. Furthermore, the serum folate concentration in pregnant women slowly declined with the gestation age in the two ethnic groups.

In addition, serum folate concentrations in pregnant Han women at 16 and 32 weeks of gestation who simultaneously received milk and FA supplements every day were higher than those of pregnant Mongolian women. However, folate concentrations of the umbilical cord bloods were not statistical difference between pregnant women of the two ethnic groups.

Serum folate concentration levels in women without FA supplementation

The level of serum folate concentration in pregnant women without FA supplementation was gradually decreased during pregnancy in the two ethnic groups. However, when women in these groups began drinking milk, the serum folate concentration increased during pregnancy. The folate level in pregnant women declined with gestation age slowly in the two ethnic groups. There were no significant differences in the serum folate concentrations of the Han and Mongolian women with milk supplementation.

Serum folate concentrations in women taking FA supplements

As show in Table 3, serum folate concentrations increased in women who received FA supplements in both ethnic groups. Although the serum folate concentration declined during pregnancy, the rate of decline was slowed due to supplementation with FA. Concentrations of folate in those women who consumed both milk and FA tablets were higher than those of women who only received milk or FA. There were statistically significant differences in the serum folate concentration between the Han and Mongolia women who were supplemented with milk and

Table 2. Supplementation can increase serum folate concentrations (SFC) in both Han and Mongolian ethnic groups (mean±SD)

Ethnicity	Groups	Non-pregnant group		5-7th weeks of gestation	
		n	SFC (nmol/L)	n	SFC (nmol/L)
Mongolian	N-FA	75	14.2±6.81	51	14.6±4.45
	Y-FA	182	17.8±9.01	252	18.5±5.29
Han	N-FA	121	15.6±6.19	54	15.5±5.54
	Y-FA	175	23.2±7.77	119	24.6±12.5

Non-pregnant group: Ethnicity, F=25.4, $p<0.01$; folic acid supplementation, F=70.6, $p<0.01$; interaction, ethnicity×FA, F=7.70, $p=0.006$. 5-7th weeks of gestation: Ethnicity, F=28.6, $p<0.01$; folic acid supplementation, F=52.8, $p<0.01$; interaction, ethnicity×FA, F=8.97, $p=0.003$. N-FA: no folic acid supplementation; Y-FA: folic acid supplementation.

Table 3. Serum folate concentrations (SFC) milk supplementation (mean±SD)

Ethnicity	Groups		Week 16 of gestation		Week 32 of gestation		Umbilical cord blood	
			n	SFC (nmol/L)	n	SFC (nmol/L)	n	SFC (nmol/L)
Mongolian	N-FA	Y-milk	65	12.2±5.81	65	10.8±4.07	66	11.0±4.80
		N-milk	95	15.8±5.55	99	15.4±6.18	118	14.6±4.40
	Y-FA	Y-milk	159	12.3±6.18	160	11.3±5.04	170	11.6±4.82
		N-milk	235	17.8±7.50	205	14.9±4.55	125	15.5±5.38
Han	N-FA	Y-milk	78	14.0±5.17	55	11.9±5.55	57	10.3±5.56
		N-milk	122	16.3±3.94	124	15.8±12.0	122	14.7±4.94
	Y-FA	Y-milk	92	14.6±5.77	123	11.8±5.53	145	10.7±5.01
		N-milk	182	23.3±13.1	177	16.9±5.79	184	15.1±5.29

N-FA: no folic acid supplementation; Y-FA: folic acid supplementation; Y-milk: milk supplementation; N-milk: no milk supplementation.

Week 16 of gestation: Ethnicity, F=25.3, $p<0.01$; folic acid supplementation, F=14.6, $p<0.01$; milk, F=145, $p<0.01$; interaction, ethnicity×Fa, F=5.08, $p=0.024$; ethnicity×milk, 1.13, $p=0.29$, milk×FA, F=18.6, $p<0.01$.

Week 32 of gestation: Ethnicity, F=6.31, $p<0.012$; folic acid supplementation, F=2.18, $p=0.14$; milk, F=162, $p<0.001$; interaction, ethnicity×Fa, F=0.13, $p=0.71$; ethnicity×milk, F=1.24, $p=0.27$, milk×FA, F=0.01, $p=0.93$.

mbilical cord blood: Ethnicity, F=8.32, $p=0.004$; folic acid supplementation, F=13.2, $p<0.01$; milk, F=151, $p<0.01$; interaction, ethnicity×Fa, F=0.12, $p=0.73$; ethnicity×milk, F=0.87, $p=0.35$, milk×FA, F=0.02, $p=0.89$.

FA, with the level in the Han women being higher than that of the Mongolian women. Meanwhile, serum folate concentrations in Han women were higher than those of Mongolian women ($p<0.01$) after supplementation with FA only (without milk) in the first trimester or pre-pregnancy period.

Serum folate concentrations in women with folate deficiency

Folate deficiency was defined as having a serum concentration of less than 6.8 nmol/L. The incidence of folate deficiency significantly decreased at 16 and 32 weeks of gestation in pregnant women compared with those who were not supplemented with milk in both ethnic groups (shown in Table 4).

Supplementation with milk enhances newborn physical parameters at birth

As show in Table 5A ,the average birth weight and height of newborns were increased by 1.9% and 0.8% ($p<0.05$), respectively, after maternal supplementation with milk, although the average Apgar score as defined by the World Health Organization did not change ($p>0.05$). In addition, there are no significant difference in birth weight and height of newborns and Apgar score between the Han and the Mongolian.

According to Table 5B, the percentage of infants of low birth weight (<2,500 g) without maternal milk supplementation was 1.8% (20/1102), which was significantly higher than that of the infants born to mothers with milk supplementation (0.8%, 7/914) ($p<0.05$). Further analysis of different low birth weight distribution groups (including ≤2,500 g, <3,000 g, ≤3,000 g, <3,500 g, ≤3,500 g) still indicated that the proportions of infants with maternal milk supplementation were generally higher than those of the infants without it ($p<0.05$-0.01). These results showed that the frequency of low birth weight was significantly decreased by maternal supplementation with milk.

DISCUSSION

Daily taking 400 μg of FA (or an equivalent amount through food including fortified milk) by women who are planning to become pregnant has been shown to reduce the rate of NTDs.[4,11,15] Here we were interested in the effect of only supplementation with milk on the serum

Table 4. Serum folate concentrations (SFC) of women with folate deficiency

Ethnicity	Group	Week 16 of gestation			Week 32 of gestation			Umbilical cord blood		
		n	Folate deficiency		n	Folate deficiency		n	Folate deficiency	
			n	%		n	%		n	%
Mongolian	N-milk	327	65	19.9	296	68	23.0	234	55	23.5
	Y-milk	215	5	2.3	209	3	1.4*	216	0	0*
X^2				35.5			47.0			57.8
p				<0.01			<0.01			<0.01
Han	N-milk	299	46	15.4	299	52	17.4	299	72	24.1
	Y-milk	139	2	1.4*	157	2	1.3*	187	0	0*
X^2				18.9			25.6			52.9
p				<0.01			<0.01			<0.01

*$p<0.01$, compared with controls with no milk supplementation. Folate deficiency was defined as having a serum concentration of less than 6.8 nmol/L. Y-milk: milk supplementation; N-milk: no milk supplementation.

Table 5A. Birth weight and height of newborns and Apgar score (mean±SD)

		n	Weight (g)	Height (cm)	Apgar score
Mongolian	Y-milk	465	3410±346	49.9±2.43	9.73±0.55
	N-milk	557	3361±368	49.2±2.37	9.69±0.76
	F		*p*=0.03	*p*=0.01	*p*=0.38
Han	Y-milk	449	3411±446	49.5±2.70	9.70±0.47
	N-milk	545	3330±421	49.0±3.30	9.67±0.77
	F		*p*=0.03	*p*=0.08	*p*=0.42
Total	Y-milk	914	3410±425	49.6±3.49	9.71±0.67
	N-milk	1102	3346±408	49.2±3.18	9.68±0.83
	F		*p*=0.01	*p*=0.04	*p*=0.28

Table 5B. Distribution of low birth weight and neonatal weight

	n	<2,500 g		≤2,500 g		<3,000 g		≤3,000 g		<3,500 g		≤3,500 g	
		n	%	n	%	n	%	n	%	n	%	n	%
N-milk	1102	20	1.8	32	2.9	129	11.7	242	22.0	656	59.5	815	74.0
Y-milk	914	7	0.8	13	1.4	81	8.9	164	17.9	496	54.3	628	68.7
X^2-test		*p*=0.04		*p*=0.03		*p*=0.04		*p*=0.03		*p*=0.02		*p*=0.01	

Y-milk: milk supplementation; N-milk: no milk supplementation.

folate concentration in pregnant women of different ethnic groups who had stopped supplementing with FA. Folate concentrations of maternal blood in the mid and late stages of pregnancy (16 and 32 weeks) and in cord blood were higher than in those who did not drink milk in the two races. This increase would be expected to decrease NTDs risk for the women of childbearing age.

Simultaneously, the effects of maternal milk supplementation on the birth weight and height of newborns was obvious, which be expected to decrease the risk of low birth weight.

Results of the study demonstrated that daily supplementation with only milk could increase the folate concentration of serum and umbilical cord blood in pregnant women with no significant difference between the Han and Mongolian ethnic groups in China. It is possible that folate bioavailability can be increased by taking milk.[17] The concentration of folate has been shown to be increased significantly by supplementing with fortified whole milk, although the bioavailability of folate from fat reduced milk or skimmed milk is higher.[20,21] Additionally, milk naturally contains folate that can influence the serum concentration of folate. However, the women in this study had stopped taking FA at 16 and 32 weeks of gestation and continued supplementing with milk for 1 month and 5 months, respectively. There were different effects on the serum folate concentration of pregnant Han and Mongolian women, possibly suggesting that the frequency of mutation in the N5,10-methylenetetrahydrofolate reductase gene (MTHFR) is higher in the Han population than in the Mongolian population in China.[22]

During the pre-pregnancy period and at the early stage of pregnancy, the folate concentration in women taking FA was significantly higher than that of women not taking FA. This result suggests that taking FA tablets can significantly increase the serum folate concentration, which is consistent with previous research.[4,11] However, the concentration of folate was not significantly higher in maternal serum at 16 and 32 weeks of pregnancy nor in fetal cord blood from FA-supplemented women without milk than that of non-supplemented women. It may be that the folate concentration was returning to a baseline value after the women stopped taking FA for up to three months during pregnancy.

Umbilical cord blood is a sample of blood taken from the umbilical cord of neonates. Not only can the cord blood reflect the metabolic status of a newborn infant, it also can be used for research on fetal development. In this study, the folate concentration in the cord blood of mothers taking FA tablets was higher than that of the group not taking FA, demonstrating that supplementation by the mother can increase the availability of folate to the baby via the cord blood. We also found that supplementation with milk could increase the folate concentration of cord blood, which further reduced the incidence of low birth weight. Low birth weight is closely related to neonatal morbidity, which can have adverse effects on cognitive function and physical development in later life.[23-25] However, whether the concentration of folate is directly related to the birth weight and height of newborns needs to be further verified. In a small sample study, providing women with regular deworming treatment and weekly iron-FA supplements before pregnancy was associated with a reduced prevalence of low birth weight.[26] However, in this trial, FA supplements had been stopped for six or seven months for these pregnant women, and the concentrations of folate were higher in the cord blood from women supplemented with milk and folate than in cord blood from non-supplemented women. We did not detect the concentration of total folate and also did not know whether the unmetabolized FA is beneficial for reducing the birth weight. As the role of unmetabolized FA in blood has been questioned in various other studies,[27-31] its impact on birth outcomes should be further evaluated through more extensive research and a larger randomized controlled trial.

In conclusion, our study suggests that women who consumed the liquid milk from pregnancy to parturition (these women have supplemented with FA from the first three months before pregnancy and after three months becoming pregnant), even though these women no longer supplemented with FA, is associated with increased serum folate concentration and reduced prevalence of low birth weight in both ethnic groups. Thus, trends in the rate of low birth weight by racial/ethnic group as a result of supplementation with FA in China should continue to be monitored.

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AUTHOR DISCLOSURES

There is no conflict interest on the part of any of the authors.

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Original Article

Effect of daily milk supplementation on serum and umbilical cord blood folic acid concentrations in pregnant Han and Mongolian women and birth characteristics in China

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每日补充牛奶对中国汉族和蒙古族怀孕妇女血清和脐带血中叶酸浓度以及新生儿特征的影响

许多研究证明补充叶酸能够有效预防神经管畸形，然而不同种族间神经管畸形的发生程度不同。中国是一个没有实施叶酸强化标准食物的多民族国家，尚不清楚补充牛奶是否对中国汉族和蒙古族怀孕妇女停止服用叶酸 1 个月和 5 个月后的血清和脐带血中叶酸含量有影响。本研究的目的是确定怀孕妇女停止服用叶酸后，每天补充液体牛奶是否能够增加血液中叶酸的含量，以及汉族和蒙古族之间是否有差别？4052 名妇女参与了此项研究，其中 3526 名妇女被确认怀孕，随机分为补充牛奶组和不补充牛奶组。结果显示补充牛奶后，无论汉族还是蒙古族，在孕 16 周和 32 周及脐带血中的叶酸含量都显著升高。补充牛奶的妇女所生婴儿的体重和身高都好于未补充牛奶妇女所生的婴儿，这可能和血清中叶酸浓度的升高有关。总而言之，每天补充牛奶能够提高中国汉族和蒙古族怀孕妇女血清中的叶酸浓度，并可能改善出生结局。

关键词：叶酸、牛奶、新生儿出生体重、出生缺陷、脐带血