

Folate, zinc, and vitamin B-12 intake during pregnancy and postpartum

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The United States Public Health Service and other groups recommend that women of child-bearing age consume 400 µg folic acid/day (1-3) to reduce the risk of bearing a child with a neural tube defect (4,5). The recently revised Recommended Dietary Allowances (RDA) distinguish between natural folate and synthetic folic acid with a pregnancy recommendation of 600 µg Dietary Folate Equivalents (DFEs)¹ (6). Despite public health campaigns, a 1999 survey showed that 87% of women in child-bearing years were not aware that adequate folic acid intake could help prevent birth defects (7). The purpose of this study is to assess whether the well-educated women seen in our hospital obstetrics clinic meet recommendations for folate, vitamin B-12, and zinc

intake during pregnancy and postpartum; determine the relative contribution of food and supplements to nutrient intake; and compare intake with red blood cell (RBC) and serum concentrations of these nutrients.

MATERIALS AND METHODS

Pregnant women age 18 to 40 years were recruited between 1994 and 1996. Subjects recorded food and supplement intake for 7 consecutive days once during the 2nd trimester, twice during the 3rd trimester and once each at 4 and 6 months postpartum (35 days total). Nutrient intake was calculated using the Nutrition Data System (NDS), versions 2.6-2.9 (Nutrition Coordinating Center, University of Minnesota, Minneapolis, Minn, released 1994-1996). At 6 months postpartum, nutrient intake for the previous year was estimated from a food frequency questionnaire (FFQ) (8).

On the day after each 7-day food record was completed, blood samples were col-

lected for RBC folate, serum vitamin B-12, and serum zinc. Blood concentrations were determined once at delivery. Samples were collected in trace-mineral-controlled tubes to guard against zinc contamination. Zinc was assayed by inductively coupled plasma/mass spectrometry at a reference lab and folate assayed in-house by a competitive assay against Lite reagent (folate bound to acridinium ester).

The data were analyzed using the repeated measures ANOVA which was performed using SAS/STAT procedure MIXED; a procedure for fitting linear models with both fixed and random effects (SAS Institute Inc., Cary, North Carolina, 1996, version 6.11). Because supplement intake was skewed, the non-parametric Wilcoxon signed rank test was used to evaluate significance.

RESULTS

Fifteen white women, age 21 to 37 years with 12 to 16 years of education, completed the study. Nine took folic acid supplements before conception and all delivered normal infants.

Total folate intake (food and supplements) was lower postpartum than during pregnancy ($P < 0.0001$) due to decreased supplemental intake ($P < 0.001$) (Table). Total folate intake (mean±SD) for women who continued folate supplementation postpartum was 911±347 µg folate/day (386±171 µg from food alone), whereas the 6 women who discontinued supplementation averaged only 222±163 µg food folate/day ($P < 0.05$). All RBC folate concentrations were within normal limits but were higher during pregnancy than postpartum ($P < 0.0001$). Folate intake and RBC folate was not correlated during pregnancy when all intakes exceeded the RDA, but was highly correlated ($r = 0.61$; $P = 0.01$) postpartum after 6 subjects discontinued their supplement intake (Figure), resulting in a greater range of intakes. Small sample size may account for the lack of correlation during pregnancy.

Zinc intake from food was similar during pregnancy and postpartum, but supplemental intake was lower postpartum ($P = 0.0508$), whereas serum concentrations were lower during pregnancy ($P < 0.0001$). Serum zinc levels for 6 subjects dropped below normal (non-pregnant) concentrations during the 3rd trimester, but all subjects were in the normal range postpartum.

Vitamin B-12 intake (food and supplements) was lower postpartum than dur-

¹DFE=1 µg food folate=0.6 µg folic acid (from fortified food or supplement) consumed with food=0.5 µg synthetic (supplemental) folic acid taken on an empty stomach.

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Table
Nutrient intake and serum values for 15 women during pregnancy and postpartum

Nutrient/Period	Food intake ^a	Supplement intake ^b	Total intake ^a	RDA	Total Intake as % RDA	Serum or RBC values ^{a,c}
Folate (μg)						(RBC, nmol/L) ^d
Pregnancy	350±154	905 (400,1,000)	1,154±471	600	192	1,226±229
Postpartum	320±164	314 (0,500) ^{***}	635±484 ^{****}	500	127	847±242 ^{****}
FFQ	328±161					(serum, μmol/L) ^e
Zinc (mg)						8.9±1.7
Pregnancy	13.5±5.3	15.0 (0.0,25.0)	25.1±11.8	15	167	12.1±1.8 ^{****}
Postpartum	13.1±5.7	4.3 (0.0,13.9) [*]	20.9±12.0 ^{**}	19	110	
FFQ	13.3±4.4					(serum, pmol/L) ^f
Vit B-12 (μg)						264±122
Pregnancy	5.8±2.3	4.0 (0.0, 6.0)	9.9±4.1	2.2	450	423±126 ^{****}
Postpartum	4.6±2.5 ^{**}	1.7 (0.0,6.0)	7.8±4.2 ^{***}	2.6	300	
FFQ	6.0±2.2					

^aMean±standard deviation.

^bMedian (25th, 75th percentiles).

^cNormal values: RBC folate >339 nmol/L; serum zinc=7.6 μmol/L; serum vitamin B-12≥111 pmol/L.

^dTo convert nmol/L RBC folate to ng/mL, multiply nmol/L by 0.441. To convert ng/mL RBC folate to nmol/L, multiply ng/mL by 2.266. RBC folate of 550 nmol/L=243 ng/mL.

^eTo convert μmol/L serum zinc to μg/dL, multiply μmol/L by 6.54. To convert μg/dL serum zinc to μmol/L, multiply μg/dL by 0.153. Serum zinc of 15 μmol/L=98μg/dL.

^fTo convert pmol/L serum vitamin B-12 to pg/mL, multiply pmol/L by 1.36. To convert pg/mL serum vitamin B-12 to pmol/L, multiply pg/mL by 0.738. Serum vitamin B-12 of 200 pmol/L=271 pg/L.

^{*}P=0.0508.

^{**}P<0.01.

^{***}P<0.001.

^{****}P<0.0001.

ing pregnancy ($P<0.001$) due to reduced intake from food ($P<0.01$). Serum vitamin B-12 concentrations were lower during pregnancy than postpartum ($P<0.0001$) even though intake was higher during pregnancy. Fourteen of the 15 subjects had serum concentrations within normal limits at all measurements.

Food record and FFQ data for the 14 women completing both measures revealed similar values for food folate (317±124 vs 328±161 μg/day, NS); vitamin B-12 (5.1±2.2 vs 6.0±2.2 μg/day, NS) and zinc (12.9±4.8 vs 13.3±4.4 mg/day, NS), respectively. The limit of agreement (mean difference±2.16 standard deviations) between FFQ and food records was 10±226 μg for folate, 0.9±3.8 μg for vitamin B-12, and 0.4±13.5 mg for zinc. The FFQ data correlated with the food record for folate ($r=0.76$; $P<0.01$) and vitamin B-12 ($r=0.67$; $P<0.01$) but not for zinc ($r=0.08$; $P>0.05$). Our FFQ data show that ready-to-eat cereal was by far the best dietary source of folic acid, providing an average of 99 μg/day. The next 2 top food sources were orange juice and skim milk, each providing approximately 25 μg followed by pizza, wheat and rye bread, white bread, and salty snacks each providing from 12 to 15 μg/day.

DISCUSSION

Current nutrient databases do not distinguish between synthetic folic acid

and naturally occurring folate, which complicates the comparison of folate intake with the new recommendations in DFEs (6,9). We compared folate intake in μg to recommendations in DFEs knowing this underestimates bioavailable intake. Breakfast cereals, which have been fortified with folic acid even before the grain fortification mandate (10), were a significant source of synthetic folic acid for our subjects (99 mg folate or 168 mg DFE), as well as for US adults (11).

Current recommendations for pregnant women are 600 μg DFE from diet to include 400 μg synthetic folic acid daily until the end of the periconceptional period (6). All 15 subjects took at least 400 μg synthetic folic acid throughout pregnancy. Six women consumed 1,000 μg or more of synthetic folic acid from prenatal or prescription supplements, levels at or above the tolerable upper intake level (6). Thus, in our sample of pregnant women, folate intake was at least adequate to meet the RDA and often higher, findings consistent with NHANES III data for pregnant women (6).

During the postpartum period most women discontinued their supplements or consumed more moderate amounts (400 to 800 μg) with one woman consuming 1,000 μg folic acid. The women who continued supplementation also

consumed more folate from foods and ate a greater amount of fortified cereal than the 6 women who discontinued supplementation.

Among the 6 women who stopped taking supplements postpartum, intakes of folate were similar to intakes reported in NHANES III: 230±7.8 μg/day for non-pregnant women age 20 to 29 and 237±9.0 μg/day for ages 30 to 39 (12), levels below the RDA. Because at least 40% of pregnancies in the United States are unplanned (13), recommendations (6) specify that all women in child-bearing years consume supplemental folate.

The recently mandated fortification passively increases folate intake. Studies have already shown that fortification improves folate status; serum folate doubled among Framingham Heart Study subjects after fortification was in place (14).

RBC folate is superior to serum folate as a biological marker because it persists for 120 days, reflecting long-term intake. RBC folate levels of our subjects were within normal limits throughout pregnancy and postpartum. High folate intakes were not reflected in correspondingly higher serum values. This is in agreement with Shane (15), who reported that high doses of folate are not retained due to a limited retention capacity of tissues.

Vitamin B-12 and zinc nutrition should be considered when promoting folic acid

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Breast-feeding Practices of Native American Mothers Participating in WIC

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A national survey on infant feeding practices revealed that Native-American mothers have a lower breast-feeding incidence and duration when compared to Whites (1). Several socioeconomic risk factors widespread in this population may contribute to this observation. Nearly one-half of Native Americans have an annual household income under the poverty level (2), only 8% have a college degree (3), and few Native Americans obtain prenatal care, especially in the first trimester (4).

The lower incidence of breast-feeding may also reflect cultural changes that have eliminated breast-feeding as a traditional practice (3). According to a recent study, about one-third of Native Americans in the United States live on a reservation and nearly one-half live in urban areas (3). Lindenberg (5) found that urbanization tends to inact changes in lifestyle and cultural norms. When Native Americans move away from reservations, they often leave behind the traditional lifestyle that supported breast-

feeding (6,7). In the past, many pregnant women were prepared for childbirth and lactation by their mothers (8). Today, Native-American women are often separated from female relatives. When this support is lost, the traditional practice of breast-feeding may shift to formula feeding (9-12).

The decline in breast-feeding among Native-American mothers is a concern to health professionals who advocate its practice (13). Higher breast-feeding rates among Native Americans can promote health in a population with many

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socioeconomic health risks (14,15). Social and cultural factors that influence Native-American mothers' infant feeding decisions need to be understood to effectively respond to the American Academy of Pediatrics position to promote breast-feeding (16). This study examined breast-feeding rates and attitudes among Native Americans enrolled in Special Supplemental Nutrition Program for Women, Infants, and Children Supplemental Food Program (WIC) in eastern Washington state.

METHODS

Women were eligible for the study if they were of Native American descent, had a child between 6 months and 5 years of age who, if breast-fed, was weaned, were enrolled in WIC, were aged 18 years or more, and were able to read and write. A pilot-tested, retrospective questionnaire was distributed to 8 WIC clinics in eastern Washington. The questionnaire assessed demographic characteristics of the sample and factors related to breast-feeding initiation and duration. The survey combined open-ended and forced answer choice items. Eligible mothers were informed about the study at a WIC appointment, and their voluntary participation in the study was sought during October 1998 through January 1999.

There were approximately 100 Native Americans eligible for this study. Fifty-five questionnaires were returned, of which 50 were complete and met the study criteria. This represents a response rate of about 50%. Data were analyzed using the Microsoft Excel 97 Analysis ToolPak (1996 Microsoft Corporation, Redmond, Wash) and Number Cruncher Statistical Systems (version 6.0, 1996, NCSS Keyville, Utah) statistical packages. Descriptive statistics were used to summarize the demographic data. χ^2 test for independence and the Fisher exact test were used to determine the significance of differences in breast-feeding initiation variables. The Spearman rank correlation coefficient was used to assess the relationships between variables. The equality or nonequality of independent sample means for certain breast-feeding duration variables were analyzed using Wilcoxon's rank sum test (Mann-Whitney *U* test). The level of significance was set at $P < .05$.

RESULTS AND DISCUSSION

Participants, who represented 9 Pacific Northwest Indian tribes, had a mean age of 27.7 ± 6.8 years and 12.2 ± 2.3 years of