

Maternal Body Mass Index, Dietary Intake and Socioeconomic Status: Differential Effects on Breast Milk Zinc, Copper and Iron Content

Leila Nikniaz¹, *Reza Mahdavi², Bahram Pourghassem Gargari³, Seyed Jamal Gayem-magami³, Zeinab Nikniaz¹

¹Student Research Committee, School of Public Health & Nutrition, Tabriz University of Medical Sciences, Tabriz-Iran

²Tabriz Pediatric Health Research Center, School of Public Health & Nutrition, Tabriz University of Medical Sciences, Tabriz-Iran

³Nutrition Research Center, School of Public Health & Nutrition, Tabriz University of Medical Sciences, Tabriz-Iran

(Received: 04 July/ Accepted: 17 Dec 2011)

ABSTRACT

Background: As breast milk micronutrients content are essential for health and growth of the infants, this study was conducted to determine the breast milk zinc, copper and iron concentrations and their possible correlations with maternal nutritional status, dietary intakes as well as socioeconomic status.

Methods: Breast milk samples and information on maternal anthropometric characteristics and dietary intake were collected from 90 Iranian lactating women with 3 different socioeconomic status who exclusively breastfed their infants. Concentrations of trace elements were analyzed using atomic absorption spectrophotometry. Nutritionist III program, Multiple Regression and ANOVA test were used for data analyses.

Results: The mean milk zinc, copper, and iron concentrations were 1.93 ± 0.71 , 0.58 ± 0.32 , and 0.81 ± 0.2 mg/l, respectively. In all three SES groups only zinc mean level was lower than the recommended range. A significant difference was observed in breast milk zinc, copper and iron concentration between high and low SES groups (Zn ($P < 0.001$), Cu ($P < 0.001$) and Fe ($P < 0.044$)) and also moderate and low SES groups (Zn ($P < 0.03$), Cu ($P < 0.001$) and Fe ($P < 0.049$)). After adjusting for maternal body mass index (BMI), socioeconomic status, mean dietary energy, zinc, copper, and iron intakes, there was a negative and significant association between maternal age and breast milk zinc ($\beta = -0.28$, $P < 0.034$), copper ($\beta = -0.18$, $P < 0.048$), and iron ($\beta = -0.22$, $P < 0.04$) concentrations.

Conclusion: In low socioeconomic group with lower mean age, breast milk mineral levels were higher than others and there was no significant correlation between mineral levels and dietary intake. Hence it is supposed that maternal age may be better predictor of breast milk mineral levels.

Keywords: Breast Milk, Zinc, Copper, Iron, Infants' growth, Socioeconomic groups

Introduction

The World Health Assembly recommends the exclusive breastfeeding of

infants until 6 months of age [1]. Human milk is a complex mixture of macronu-

trients and micronutrients that should provide the infant with a nutritionally complete food [2]. Minerals are essential micronutrients for growth and development of healthy tissues [3], and it has been suggested that trace element deficiencies can lead to impaired growth during infancy and childhood [4]. Iron (Fe) and zinc (Zn) deficiency are public health concerns during infancy, especially in developing countries [5].

Human milk trace element content differs from region to region [3] and it probably would be affected by socioeconomic status (SES) [4]. The Honduran mothers belonging to low socioeconomic status had significantly higher breast milk zinc and copper concentrations [6]. However in India, the zinc and copper (Cu) concentrations in milk of women from the low-income group were lower than that of the high-income group [4].

The influence of maternal diet and nutritional status on the quality and quantity of their milk is a frequent topic of discussion [7, 8]. Studies on humans about the effect of maternal diet on the concentrations of iron, zinc, and copper in breast milk have shown the mixed results [6, 9].

Little is known about the breast milk concentrations of essential trace elements in subjects belonging to different socioeconomic status. Therefore, this study determines the breast milk zinc, copper and iron concentrations and their possible correlations with maternal nutritional status, dietary intakes and socioeconomic status.

Material and Methods

Study Population

In this descriptive-analytic study, ninety lactating women were recruited from urban areas of Tabriz- Iran who exclusively breast-fed their infants aged 90–120 days, in April 2007. The research sample included all mothers in a defined population of five urban health centers who were admitted for their infants' vaccination.

Health centers included in this study were located in three different SES districts. From the data provided by the East Azerbaijan Province Health Center, three districts within the metropolitan area of Tabriz were identified. These three districts are inhabited by citizens with distinguished SES and consequently this is reflected on the SES of the mothers. In addition, mothers were recruited from these centers after completing a socioeconomic questionnaire including questions about occupation status of husband (manual, non-manual worker, unemployed, and retired), acquisition of house and personal car, motorbike, black and white TV (B/W TV), color TV, refrigerator, freezer, vacuum cleaner and washing machine, and subjects' education level ranging from "primary school" to "university degree". All mothers were categorized in 3 socioeconomic groups (low, intermediate, and high).

The criteria for inclusion of mothers were no trace elements supplement intake, and have infants who were full term and exclusively breastfed aged 90–120 days, with normal birth weight, and with no chronic disease.

The study protocol was approved by the Ethics Committee of Tabriz University of Medical Science. All subjects were informed about the content of the study and if they agreed to participate, a written informed consent was obtained.

Determination of Trace Elements in Breast milk

Breast milk (10–15 ml) samples were collected into metal free tubes by self-expression before nursing the baby in the morning. The samples were kept at 4°C and transferred to zinc-free, screw-cap plastic tubes and frozen within 1 day at –20°C before extraction. Breast milk samples were wet-ashed and analyzed according to Clegg et al. [10]. Samples were thawed, mixed thoroughly, and digested in ultrapure concentrated nitric acid (Fisher,

Los Angeles) at room temperature for 96 h and then at sub-boiling temperature for 6–9 h. Iron, zinc, and copper concentrations were determined by atomic absorption spectrometry (Chem Tech Analytical-2000 A.A.A.). Recovery assays were carried out to check the accuracy of the method. The recovery percentages for zinc, copper, and iron were 95.6, 97.1, and 98.2, respectively.

Data Collection from Mothers

Information on food intake was collected by using a 24-h recall method for 3 days (one weekend day included). Dietary intake of subjects was analyzed by nutritionist III software program. Demographic data (i.e. place of residence and age), and clinical data (i.e. health status) were obtained through interview. The body mass index (BMI) was calculated as weight (kg) divided by height (m²).

Statistical Analysis

Results are presented as mean±SD values. Mean between groups were compared using analysis of variance and *t* test. Multiple linear regressions using the backward technique were used to analyze the association of each potential factor with zinc, copper, and iron concentrations in breast milk.

Results

Descriptive data of 90 mothers in 3 SES groups are presented in Table 1. The average of BMI was within the overweight range in different groups. The mothers' age in high SES group was significantly higher than the moderate and low SES groups ($P<0.001$).

Mean breast milk concentrations and daily dietary intake of zinc, copper and iron are shown in Table 2. The mean energy intake in all 3 groups was significantly ($P<0.05$) less than required daily intake (RDA) recommendation (2730 kcal/day). The percentage of energy from

different macronutrients was in the normal recommended range.

Analysis of variance showed significant difference in breast milk zinc ($P<0.004$), copper ($P<0.001$), and iron ($P<0.048$) concentration in three SES groups. Tukey post-hoc comparisons of the three groups indicated a significant difference in breast milk zinc, copper and iron concentration between high and low SES groups (Zn($P<0.001$), Cu ($P<0.001$) and Fe ($P<0.044$)) and also moderate and low SES groups (Zn($P<0.03$), Cu ($P<0.001$) and Fe ($P<0.049$)).

Breast milk iron and copper content were in the recommended range [11]. Infants less than 6 months of age require about 2 mg per day of zinc. This recommended allowance corresponds to levels of 3 to 5 mg/l of zinc in breast milk [11]. In all collected breast milk samples, the zinc levels were lower than 3 mg/l.

As indicated in Table 2, in all three groups, the mean dietary zinc and copper intakes of mothers were significantly less ($P<0.05$) than RDA recommendations (zinc (6.1 vs. 12 mg/d), copper (1.19 vs. 1.3 mg/d)). The mean dietary iron intake was significantly ($P<0.001$) higher than RDA recommendation (11.1 vs. 9 mg/d). No significant differences were found between mean daily intakes of these nutrients in SES groups.

Table 3 represents the association of different factors with breast milk mineral levels. In all subjects, after adjusting for maternal mean dietary energy, zinc, copper, and iron intakes, BMI and SES, there was a negative and significant association between maternal age and breast milk zinc ($\beta=-0.28$, $P<0.034$), copper ($\beta=-0.18$, $P<0.048$), and iron ($\beta=-0.22$, $P<0.04$) concentrations.

However no significant association was found between maternal BMI, age, mean dietary energy, zinc, copper, and iron intakes with the zinc, copper, and iron concentrations in mothers' breast milk of each socio economic groups (Table 4).

Table 1: Maternal Descriptive Data in different SES (mean±SD)

Variables	Socioeconomic status			
	Low (n=30)	Moderate (n=30)	High (n=30)	Total (n=90)
* Age (yr)	26.01±6.1 ^a	27.6±4.7 ^b	31.2±6.7 ^c	28.2±5.8
Weight(kg)	65.4±14.7	64.9±10	67.2±12.5	65.7±12.4
Height (cm)	157.4±8.1	155.7±6.4	158.5±4.6	157.2±6.3
BMI (kg/m ²)	26.4±5.5	26.8±3.8	26.8±4.5	26.7±4.6

*(ANOVA) Significant difference between groups ($P<0.05$)

*(Tukey test) Significant difference between ac ($P<0.001$) and bc ($P<0.02$)

Table 2: Mean breast milk Zn, Cu and Fe concentrations and their daily dietary intake in different SES groups

Variables	Socioeconomic status			
	Low (n=30)	Moderate (n=30)	High (n=30)	Total (n=90)
* Breast milk Zn concentration (mg/l)	0.71 ^a ±2.3	0.7 ^b ±1.9	0.73 ^c ±1.6	1.93±0.71
*Breast milk Fe concentration (mg/l)	0.21 ^a ± 0.9	0.22 ^b ± 0.8	0.18 ^c ± 0.75	0.81±0.2
* Breast milk Cu concentration (mg/l)	0.51 ^a ± 0.85	0.24 ^b ± 0.47	0.23 ^c ± 0.41	0.58±0.32
Dietary Zn intake (mg/d)	2.5±5.8	2.4±6.1	2.2±6.5	2.3±6.1
Dietary Fe intake(mg/d)	6.2±12.1	6.1±11	3.1±10.5	11.1±5.1
Dietary Cu intake(mg/d)	0.75±1.17	0.77±1.15	0.6±1.25	1.19±0.7

*(ANOVA) Significant difference between groups ($P<0.05$)

*(Tukey test) Significant difference between ac and ac and ab ($P<0.05$)

Table 3: The association of different factors with breast milk Zn, Cu and Fe levels

Variables	Breast milk Zn content		Breast milk Cu content		Breast milk Fe content	
	β	P -value	β	P -value	β	P -value
Daily energy intake (Kcal)	0.26	0.37	0.17	0.52	0.08	0.69
Maternal BMI(kg/m ²)	0.31	0.46	0.24	0.63	0.12	0.57
Maternal age (Year)	0.28-	0.034*	0.18-	0.048*	0.22-	0.04*
Socioeconomic status						
High	0.1	0.39	0.15	0.16	0.29	0.56
Moderate	0.07	0.61	0.1	0.22	0.14	0.23
Low	0.08	0.53	0.29	0.4	0.05	0.7
Dietary Zn intake (mg/d)	0.13	0.11				
Dietary Cu intake (mg/d)			0.16	0.5		
Dietary Fe intake (mg/d)					0.11	0.12

*Significant correlation between maternal age and breast milk Zn, Cu and Fe concentration after adjusting for daily energy, Zn, Cu and Fe intake, maternal BMI and Socioeconomic status

Table 4: The association of different factors with breast milk Zn, Cu and Fe levels in different SES groups

Variables		Daily energy intake (Kcal)	Maternal BMI (kg/m ²)	Maternal age (yr)	Dietary Zn intake (mg/d)	Dietary Cu intake (mg/d)	Dietary Fe intake (mg/d)
Breast milk mineral levels in different socioeconomic status (mg/l)	Zn	β	0.08	0.18	-0.24	0.09	
		PV	0.66	0.40	0.14	0.83	
	Cu	β	0.02	-0.17	-0.22		0.16
		PV	0.91	0.55	0.06		0.69
	Fe	β	0.23	0.41	-0.27		0.53
		PV	0.37	0.48	0.15		0.38
	Zn	β	0.51	0.11	-0.18	0.15	
		PV	0.46	0.40	0.09	0.57	
	Cu	β	0.35	-0.14	-0.23		0.27
		PV	0.67	0.77	0.17		0.31
	Fe	β	0.45	0.14	-0.33		0.2
		PV	0.09	0.50	0.06		0.64
	Zn	β	0.10	0.36	-0.3	0.14	
		PV	0.63	0.13	0.08	0.73	
	Cu	β	0.34	0.19	-0.4		0.14
		PV	0.71	0.37	0.12		0.22
	Fe	β	0.41	0.13	-0.39		0.60
		PV	0.68	0.87	0.06		0.47

Discussion

In our study, mean zinc concentration (1.93 ± 0.71 mg/l) was lower than 4.1 mg/l reported in 12–20 weeks postpartum for Austria [12], 1.17–5.31 mg/l for Canada [13], 2.0 mg/l for Texas [14]. The copper levels of mothers' breast milk (0.58 ± 0.32 mg/l) were higher than the levels reported elsewhere which was 0.36–0.47 mg/l in Korea [15] and 0.09–0.27 mg/l in Taiwan [16], but it was lower than the reported values (0.86 mg/l) from Austria [12]. Mean iron concentration (0.81 ± 0.2 mg/l) was higher than values (0.46 mg/l) reported for Austria [12] and 0.09–0.22 mg/l for Taiwan [16].

The data for trace element content of human milk differ widely from region to region. Variations of trace element concentrations in breast milk may be due to differences in sampling, analytical techniques, dietary intake, type and dose of trace element supplementation, and also socioeconomic status of subjects [3,8].

In this study, breast milk zinc, copper and iron concentration in high SES group was significantly lower than Low SES group and also it was insignificantly lower than moderate SES group.

The results of study in India showed that the copper and zinc concentrations in

mother's milk from the low-income group were lower than that of the high-income group [4]. To justify this difference, it seems that BMI of Indian mothers belonging to the low SES was extremely lower than BMI of subjects belonging to low SES group in this study.

However, similar results were found in the study conducted by Domellöf et al. who showed that the Honduran mothers belonging to low socioeconomic status who were younger than Swedish mothers had significantly higher breast milk zinc and copper concentrations [6].

Similar to the Domellöf et al. study, our subjects belonging to the low SES group were younger than the others. Besides, negative and significant correlation between maternal age and breast milk trace elements concentration was seen. Therefore, it could be proposed that maternal age is one of the important factors affecting breast milk trace element concentration. We could not find any other human study evaluating the effect of maternal age on trace elements concentration in breast milk but some animal studies have shown age related reduction in intestinal absorption of zinc and copper which may be due to changes in gene expression of transfer proteins and increased cholesterol in intestinal epithelial cells [17, 18].

Dietary zinc, copper, and iron intakes of our subjects in three SES groups were lower than the dietary intake of the American and Nepalese mothers [19]. Similar to the results of the most previous studies [6, 9, 20- 21], there was no correlation between maternal dietary zinc copper, and iron intake and breast milk zinc, copper, and iron concentration which may be because of active transport mechanisms in the mammary gland for all three minerals.

As conclusion, the concentration of studied trace elements in milk of mothers with low SES was higher than moderate and high SES. The observed significant correlation between breast milk mineral concentrations and maternal age but not intake suggest that mothers' age was one

of the important factors affecting breast milk trace element concentration. Hence more studies are needed to clarify the mechanisms mothers' age affecting breast milk trace element concentration.

In addition, more trials are needed to determine whether Iranian diet could supply zinc alone or whether supplemental zinc should be given to infants before 4 months old and/or whether, after 4 months, complementary food should be fortified with zinc.

Acknowledgments

The authors wish to thank the Tabriz Pediatric Health Research Center for financial support. This study would not have been possible without the help and participation of the health centers and all the mothers who volunteered their milk samples. This article was written based on a dataset of MSc thesis, registered in Tabriz University of Medical Sciences. The authors declare that there is no conflict of interests.

References

- [1] World Health Assembly. Infant and young child nutrition. Resolution WHA 54.2, 2001.
- [2] Trahms C, Mackean K. Nutrition during infancy. In: Kathleen Mahan L, Escott Stump S, editors. Krause's food, nutrition, and diet therapy. 11th ed. Saunders: Philadelphia; 2008.
- [3] Farida M, Al-Awadi STS. Trace-element status in milk and plasma of Kuwaiti and non-Kuwaiti lactating mothers. *Nutrition* 2000; 16: 1069–1073.
- [4] Rajalakshmi K, Srikantia SG. Copper, zinc, and magnesium content of breast milk of Indian women. *Am J Clin Nutr* 1980; 33: 664–669.
- [5] Domellöf M, Hernell O. Iron-deficiency anemia during the first two

- years of life. *Scand J Nutr* 2002; 46: 20–30.
- [6] Domellöf M, Lönnerdal B, Dewey KG et al. Iron, zinc, and copper concentrations in breast milk are independent of maternal mineral status. *Am J Clin Nutr* 2004; 79: 111–115.
- [7] Picciano MF. Pregnancy and lactation: physiological adjustments, nutritional requirements and the role of dietary supplements. *J Nutr* 2003; 133:1997.
- [8] Mahdavi R, Nikniaz I, Gayemmagami SJ. Association between Zinc, Copper, and Iron Concentrations in Breast Milk and Growth of Healthy Infants in Tabriz, Iran. *Biol Trace Elem Res* 2010; 135:174–181.
- [9] Lönnerdal B. Effects of maternal dietary intake on human milk composition. *J Nutr* 1986; 116: 499–513.
- [10] Clegg MS, Keen CL, Lönnerdal B et al. Influence of ashing techniques on the concentration of trace elements in animal tissues. 1: wet ashing. *Biol Trace Elem Res* 1981; 3: 107–115.
- [11] Picciano MF, McDonald SS. Lactation. In: Shills ME, editor. *Modern nutrition in health and disease*. 10th ed. Kluwer: Philadelphia; 2006.
- [12] Krachler M, Li FS, Rossipal E, Irigolic KJ. Changes in the concentration of trace elements in human milk during lactation. *J Trace Elem Med Biol* 1998; 12: 159.
- [13] Friel JK, Andrews WL, Jackson SE et al. Elemental composition of human milk from mothers of premature and full-term infants during the first 3 months of lactation. *Biol Trace Elem Res* 1999; 67: 225.
- [14] Hannan MA, Faraji B, Tanguma J et al. Maternal milk concentration of zinc, iron, selenium, and iodine and its relationship to dietary intakes. *Biol Trace Elem Res* 2009; 127: 6–15.
- [15] Ko YS, Om AS. Analysis of the concentrations of trace elements in colostrum, transitional and mature milk of Korean women. *J Trace Elem Exp Med* 1998; 11: 407.
- [16] Lin TH, Jong YJ, Chiang CH, Yang MH. Longitudinal changes in calcium, magnesium, iron, copper and zinc in breast milk of women in Taiwan over a lactation period of one year. *Biol Trace Elem Res* 1998; 62: 31.
- [17] Coudray F, Rambeau M, Claude Tressol J, Gueux E, Mazur A, Rayssiguier Y. The effect of aging on intestinal absorption and status of calcium, magnesium, zinc, and copper in rats: A stable isotope study. *J Trace Elem Med Biol* 2006; 20: 73–81.
- [18] Teillet L, Tacnet F, Ripoche P, Corman B. Effect of aging on zinc and histidine transport across rat intestinal brush-border membranes. *Mech Ageing Dev* 1995; 14: 151–67.
- [19] Moser PB, Reynolds RD, Acharya S et al. Copper, iron, zinc, and selenium dietary intake and status of Nepalese lactating women and their breast-fed infants. *Am J Clin Nutr* 1998; 47: 729–734.
- [20] Moser PB, Reynolds RD. Dietary zinc intake and zinc concentrations of plasma, erythrocytes, and breast milk in antepartum and postpartum lactating and nonlactating women: a longitudinal study. *Am J Clin Nutr* 1983; 38: 101–108.
- [21] Celada A, Busset R, Gutierrez J et al. No correlation between iron concentration in breast milk and maternal iron stores. *Helv Paediatr Acta* 1982; 37: 11–16.