

Zinc and Copper Concentrations in Human Milk and Infant Formulas

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Abstract

Objective: Available accurate data on the concentrations of copper (Cu) and zinc (Zn) in human milk throughout lactation and infant formulas is important both for formulating nutritional requirements for substances and to provide a base line for the understanding the physiology of their secretion. The objective of this study was to analyze the concentrations of zinc and copper in infant formulas and human milk during prolonged lactation. Levels of these metals were examined in relation to selected parameters such as age, weight, height, education and occupation of mothers.

Methods: Thirty mothers referred to the selected clinics in Tehran entered the study. Human milk samples were collected at 2 months postpartum. Zinc and copper concentrations were determined by atomic absorption spectrophotometer.

Findings: The mean values of Zn and Cu in human milk were 2.95 ± 0.77 mg/L and 0.36 ± 0.11 mg/L. The mean values of Zn and Cu in infant formulas were 3.98 ± 0.25 mg/L and 0.53 ± 0.17 mg/L.

Conclusion: No significant relationship was found between levels of trace elements in human milk and evaluated parameters such as age, weight, height, education and occupation of mothers. The concentrations of zinc and copper in breast milk were lower than those reported in the literature.

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Key Words: Human Milk; Infant Formula; Zinc; Copper; Breast Milk; Nutritional Requirements

Introduction

Human milk represents the most suitable pattern of nutrients to meet the physiological requirements of the young infant^[1]. Hence, an

accurate and complete knowledge of the composition of human milk is essential to understand more adequately the nutrient requirements of the infant as well as for

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developing more adequately defined formulas to be used as a substitute for human milk^[2].

Trace elements have an essential role in growth and development. Although they are required only in small amounts, the intake may not always be adequate. Where food intake may be restricted by cultural, economical, and climatologically factors, populations need to be studied to determine how a limited dietary intake affects health^[3]. Mammary glands get zinc (Zn) from the blood, control its excretion from the breast milk by several mediators^[4], motivate the same process for copper (Cu), and regulate its transport from membrane and its excretion from the milk^[5,6]. Deficiency of trace elements such as zinc and copper can occur in infants for different reasons. It has been reported that zinc intake by infants from breast milk is inadequate during the weaning period, especially if weaning foods are introduced at an early stage. Similarly, copper deficiency can occur because of infants' inability to use absorbed copper rather than a dietary insufficiency of the element.

The bioavailability of essential elements to infants depends solely on the trace-element content of the breast milk, length of breast feeding and physiological factors such as nutrient absorption and nutrient supplementation of the mother^[3]. Decrease of zinc causes growth stoppage^[7] and its reduction damages immune system^[8, 9]. The incidence of cytomegalovirus infection is related to Zn deficiency^[10]. Cu deficiency increases the free radicals and leads to reduction of defense against oxidative stress^[11]. Reduction of Zn and Cu in infant are associated with iron deficiency and leads to several complications^[12, 13].

The main objective of this study was to measure the total concentrations of Cu and Zn in human milk and infant formulas. Levels of these metals were examined in relation to selected parameters such as the course of lactation, mother's age and mother's weight.

Subjects and Methods

Thirty mothers, who intended to breast-feed for at least 2 months postpartum, were monitored

during pregnancy. The characteristics and goals of the study were explained in detail and informed consent was obtained from all subjects before inclusion in the study. They were non smokers with normal pre pregnancy weight and weight gain during pregnancy.

Demographic characteristics of the mothers were recorded including maternal age, maternal height as well as maternal weight at the beginning and at the end of pregnancy. Smoking habits, place of residence, education, occupation, number of children, and supplement intake during pregnancy, were also recorded.

The study protocol was in accordance with the guidelines of the Ethical Committee, Faculty of Medicine, and Tehran University of Medical Sciences.

Sample Collection: Breast milk sampling was done according to Leotsinidis^[14]. 20 ml of milk was expressed manually into plastic container and frozen immediately at -20°C until analysis was carried out.

Infant formula samples from two major brands were taken randomly from the local market in Tehran followed by sample preparation as described by Hua^[15].

Metal Analysis: A known volume of milk (10ml) was lyophilized in polyethylene tubes and digested under pressure with nitric acid (MERK suprapure). The digested sample was quantitatively transferred to clean polyethylene tubes. The volume was restored in the original volume (10ml) with high purity water. The content of copper and zinc was determined by flame atomic absorption spectrophotometer (Perkin Elmer 3110).

Statistical analysis: Results are presented as mean (SD) values. One-way analysis of variance followed by Student's t test was used to compare the Mean values of different groups. A value of $P < 0.05$ was accepted as statistically significant.

Findings

Zinc and copper concentrations in breast milk (n=30) and infant formulas (n=2) are presented in Table 1 and demographic characteristics of the mothers are shown in Table 2.

Table 1: Zinc and copper concentrations in breast milk and infant formulas

Constituent Trace elements	Human milk (n=30)	Infant formulas (n=2)	P- value
Zinc (Mean \pm SD) (mg/L)	2.95 \pm 0.77	3.98 \pm 0.25	0.19
Copper (Mean \pm SD) (mg/L)	0.36 \pm 0.11	0.53 \pm 0.17	0.16

SD: Standard Deviation

Comparing the concentrations of Zn and Cu in human milk to those in infant formulas, no significant difference was found ($P>0.05$). No statistically significant difference was found between mean Zn and Cu concentrations in breast milk and maternal weight ($P>0.05$). No statistically significant difference was found between mean Zn and Cu concentrations and maternal height ($P>0.05$), neither was a correlation observed between mean Zn and Cu concentrations and maternal age ($P>0.05$). No statistically significant difference was found between mean Zn and Cu concentrations and mother's level of education ($P>0.05$).

No statistically significant difference was found between mean Zn and Cu concentrations and mother's occupation ($P>0.05$).

Discussion

The data for trace-element content of human milk differ widely from region to region. These variations may be due in part to differences in sampling and analytical techniques rather than to geographic variation. However, these

technical factors did not contribute to the variation in the present data because we have achieved satisfactory accuracy and precision in our analytical methods.

In human milk most of the Zn and Cu is bound to casein and serum albumin, respectively. It is noteworthy that no report exists describing zinc deficiency in full term infants fed with human milk, although calculated zinc intake of infants from human milk is less than 50% of the RDA^[16]. Copper deficiency has not been observed in preterm and term infants fed with human milk. Copper is a recent addition to many infant formulas and little is known about its bioavailability^[16]. No significant effect of supplementation on human milk metals was observed in the literature^[17, 18].

In the present study, no statistically significant difference was found between mean Zn and Cu concentrations and maternal age as well as previous history of lactation. This was in contrast to findings of Picciano^[19] that found higher concentrations of zinc and copper in human milk. In addition, they reported that milk from older mothers (>30 yr) was higher in zinc and copper content than that from younger mothers (20 to 30 yr)^[19].

The influence of maternal age on these elements in breast milk was controversial that Zn concentration in breast milk of mothers aged >30 years was higher than of younger mothers aged 20–29 years^[3]. In contrast, we could not find any difference in the Zn and Cu concentrations between age groups in this study.

Comparing the concentrations of Zn and Cu in human milk to those in infant formulas, no statistically significant difference was found between them ($P>0.05$).

Given the lower bioavailability of zinc from formulas compared with human milk, the recommended dietary allowance may be

Table 2: Demographic characteristics of the mothers (No=30)

Demographic characteristics	Mothers	No (%)
Education	Elementary	4 (13.3)
	Secondary	5 (16.6)
	University	21 (70)
Occupation	Housewife	26 (89.7)
	Other	3 (10.3)
Smoking	Yes	0
	No	30 (100)

marginal. A greater quantity of Zn is required in a formula to produce the same metabolic response as with human milk feeding because of differences in bioavailability. Citric acid and picolinic acid have been proposed as possible ligands in human milk although several reports have suggested that proteins in the formula inhibited Zn absorption. The high iron content of some formulas may also reduce Zn absorption; formula-fed infants have a lower zinc status than breast-fed infants^[16].

No significant correlation was found between maternal zinc intake and the concentration of zinc in breast milk in the literature^[16]. This is not surprising since no difference in human milk zinc concentration was reported for a group of women who had zinc intake in excess of the RDA compared with women whose diet provided half this amount^[19]. Literature concerning various factors affecting metal concentrations in breast milk is in general controversial^[19].

Also there was no significant correlation between plasma zinc or erythrocyte zinc concentration of breast milk in the literature^[19]. This lack of correlation would suggest that some specific mechanism exists to regulate the concentration of zinc in breast milk. This mechanism may be hormonal^[20]. Henkin et al^[20, 21] have suggested prolactin may have a role. Further investigation is needed to clarify this relationship.

Conclusion

In this study, comparing the concentrations of Zn and Cu in human milk to those in infant formulas, no significant difference was found. Also no statistically significant difference was found between mean Zn and Cu concentrations and demographic characteristics of the mothers. The element levels in two powder formulas analyzed were higher than the average values obtained for the breast milk and their concentrations in human milk samples were significantly lower than reported data from other countries.

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Conflict of Interest: None

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