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Maternal and Cord Blood Serum Levels of Zinc, Copper, and Iron in Healthy Pregnant Jordanian Women

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Altered plasma levels of zinc, copper, and iron during pregnancy are known to have profound effects on pregnant women and their neonates. The status of these elements is not known in pregnant women in Jordan. During the three trimesters of pregnancy, blood specimens were collected from 186 healthy pregnant women aged 17–45 years and from cord blood of 92 of their neonates. The mean neonatal birth weight was 3.34 ± 0.44 kg. Maternal and cord blood serum levels of zinc, copper, and iron were determined by atomic absorption spectrophotometry, and hemoglobin concentration was determined by hematology cell counter. The results indicate significantly lower serum zinc levels and higher copper and iron levels in cord blood than in maternal blood. During the three trimesters of pregnancy, the serum levels of zinc and copper significantly decreased and increased, respectively, whereas the levels of serum iron were unchanged. Significant positive correlation was observed only between zinc levels of cord blood and birth weight. During third trimester, the mean serum levels of zinc and iron were significantly lower in anemic pregnant women (group I: Hb less than 11.0 g/dL, n = 36) than that in nonanemic pregnant women (group II: Hb > or = 11.0 g/dL, n = 56). There was no noticeable difference between group I and group II regarding cord blood parameters on one hand and neonatal birth weight on the other hand. Similar significant positive correlation was observed between serum zinc levels of cord blood and birth weight in both groups. These results indicate that Jordanian women during pregnancy follow a well-balanced and adequate diet regime. J. Trace Elem. Exp. Med. 17:1–8, 2004.

Key words: trace elements; birth weight; hemoglobin; Jordan

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INTRODUCTION

Minerals and trace elements, such as zinc, copper, iron, selenium, calcium, magnesium, and other micronutrients, have significant influence on the health of pregnant women and the growing fetus [1]. In developing countries, the prevalence of iron deficiency anemia in pregnant women ranges from 35% to 75%, and is recognized as the most common nutritional problem in the world [2,3]. During pregnancy, iron needs are usually very high to meet the requirements for the fetus, placenta, and maternal red cell expansion. Such demands cannot be met by diet alone, particularly in developing countries where diet is usually low in bioavailable iron; therefore, iron supplements are commonly recommended during pregnancy. Worldwide, poor pregnancy outcome has been most commonly associated with anemia caused by low plasma levels of iron [4,5]. Recently, the importance of zinc and other micronutrients in relation to pregnancy outcomes and fetal health have been the concern of many studies [1,6].

Severe maternal zinc deficiency has been associated with spontaneous abortion and congenital malformation, whereas milder forms of zinc deficiency have been associated with low birth weight, intrauterine growth retardation, and preterm delivery [7,8]. Additionally, low plasma zinc has also been reported to correlate with pregnancy complications, such as prolonged labor, hypertension, and postpartum hemorrhage [9]. Because pregnant women, especially in developing countries, are considered as a high-risk group for iron and zinc deficiency, maternal zinc supplementation has been suggested by several groups as one possible nutritional intervention during pregnancy to improve pregnancy outcome [10].

Although most of the studies were mainly focused on maternal iron and zinc and their correlation with poor pregnancy outcome, others were concerned with copper and its correlation with pregnancy and birth defects [11,12]. The importance of copper for prenatal development was first demonstrated by studies of diseases in lambs and other animals called enzootic ataxia, which is characterized by various neurological, skeletal, and connective tissue abnormalities [11]. In human adults, severe copper deficiency is relatively rare, whereas signs of moderate copper deficiency were observed in human infants under a variety of conditions [13]. Copper deficiency caused by inadequate maternal dietary intake is very rare, whereas moderate copper deficiency attributed to secondary causes, such as disease states, drug interactions, and nutritional genetic factors, are more common and may result in pregnancy complications [11].

In Jordan, iron deficiency anemia is considered a major health problem because it has been reported to occur at a rate of about 35% among pregnant and lactating women [14–16]. Reports from the World Health Organization and the Ministry of Health of Jordan have shown that the high prevalence of iron deficiency anemia in pregnant women and in their infants was most commonly seen in Palestinian refugees camps and in those attending government-provided maternal and child health clinics throughout Jordan [14–16]. The status of trace elements in Jordanian pregnant women attending private maternity clinics is not known. In this work, we present data pertaining to the blood levels of zinc, copper, and iron in healthy Jordanian pregnant women in addition to their neonates.

MATERIALS AND METHODS

A total of 186 middle-class pregnant Jordanian women aged 17–45 years, mean 27 ± 4.9 who were attending private obstetric and gynecology clinics in Amman city were investigated for analysis of plasma levels of trace elements. A history sheet was completed where data pertaining to personal and demographic factors were recorded. Informed written consent was obtained from all qualified pregnant women explaining the purpose of the study and the confidentiality of collected data and results. Pregnant women on modified diet or on zinc supplements were excluded from the study. All investigated women were on folate supplementation as a routine measure to prevent the development of neural tube defects. Iron and multivitamins, however, were given to those who had hemoglobin levels below 11.0 g/dL sometimes during their second trimester. At term, weights of 92 neonates delivered by participating women were obtained from their clinical chart.

Biochemical Investigation

Blood specimens were collected from participating women during each of the three trimesters; 52 samples from pregnant women in their first trimester, 42 samples from pregnant women in their second trimester, and 92 samples from pregnant women in their third trimester. At term, 92 cord blood specimens were collected from neonates of the third-trimester mothers. Blood specimens were collected in metal-free plain tubes (Royal blue, Becton-Dickinson, Rutherford, NJ, USA) and in EDTA tubes. Plain tubes were centrifuged (1100 × g) for 15 min at 3500 rpm and the serum was separated and kept in trace elements-free tubes and stored at −20°C until analysis. Hemoglobin (Hb) concentrations were determined on all EDTA specimens using a hematology cell counter. Pregnant women investigated during their third trimester were divided into two groups according to their Hb results; group I were those with Hb values less than 11.0 g/dL and group II were those with Hb values equal to or more than 11.0 g/dL. Maternal and cord blood serum levels of zinc, copper, and iron were determined by atomic absorption spectrophotometry.

Data Analysis

Data were analyzed by means of one-way analysis of variance and by multiple comparison using computer statistical analysis software (STATISTICA for Windows, 1995; Stat Soft Inc, OK). Data are expressed as the mean ± SD, and $P < 0.05$ was considered statistically significant.

RESULTS

This study was conducted on a group of healthy Jordanian pregnant women who gave birth to healthy neonates through normal vaginal delivery. The mean age of studied pregnant women was 27 ± 4.9 years, and the mean birth weight of neonates was 3.34 ± 0.44 kg. The mean values of serum levels of zinc, copper,

TABLE I. Mean Serum Levels of Zinc, Copper, Iron, and Hb Concentration in Maternal and Cord Blood

	Maternal blood			
	First trimester (n = 52)	Second trimester (n = 42)	Third trimester (n = 92)	Cord blood (n = 92)
Zinc (μg/dL)	77 ± 16	73 ± 14	68 ± 10	114 ± 23
Copper (μg/dL)	175 ± 42	226 ± 51	236 ± 36	49 ± 24
Iron (μg/dL)	69 ± 26	68 ± 19	74 ± 21	116 ± 17
Hb (g/dL)	11.4 ± 1.1	10.8 ± 1.0	11.2 ± 1.4	15.7 ± 2.6

and iron in each of the three trimesters of pregnant women and in cord blood are presented in Table I. As shown in the table, serum zinc levels during the third trimester were significantly lower than that during the first and second trimesters ($P < 0.05$). There was no significant difference between the first and second trimesters in terms of zinc levels. Zinc levels of cord blood were higher than that of maternal blood ($P < 0.01$). Serum copper levels of the second and third trimesters were higher than that in the first trimester ($P < 0.001$). No significant difference was observed between the second and third trimesters in terms of copper levels. Copper levels in cord blood were lower than that of the maternal blood ($P < 0.001$). No significant difference was observed between serum iron levels among the three trimesters; however, cord blood iron levels were higher than that of the maternal blood ($P < 0.01$). Hb concentrations in the second trimester were significantly lower than that of the first and third trimesters ($P < 0.01$ and < 0.05, respectively). No significant correlation was observed between serum levels of iron, zinc, or copper of the pregnant women studied at their third trimester on the one hand and their neonatal birth weight on the other hand. However, Figure 1 demonstrates a statistically significant positive correlation between cord blood level of zinc and birth weight ($r = 0.7225$ and $P < 0.001$).

Table II demonstrates the biochemical findings and birth weight in the two Hb-based groups of pregnant women studied during their third trimester. Group I included 36 (39%) pregnant women with Hb concentrations below 11.0 g/dL and group II included 56 (61%) with Hb concentrations equal or above 11.0 g/dL. The table demonstrates that maternal serum levels of iron and zinc in group I were lower than those in group II ($P < 0.05$). No significant difference was observed for maternal serum copper levels in both groups. Additionally, no statistically significant difference was detected between group I and group II regarding all parameters of cord blood and average birth weight. However, a statistically significant positive correlation was observed between cord blood levels of zinc and birth weight in both groups (group I: $r = 0.6060$, $P < 0.001$; group II: $r = 0.7115$, $P < 0.001$; Fig. 1).

DISCUSSION

It is well-established that physiologic, metabolic, and hormonal changes during pregnancy affect the metabolism and body needs for micronutrients and

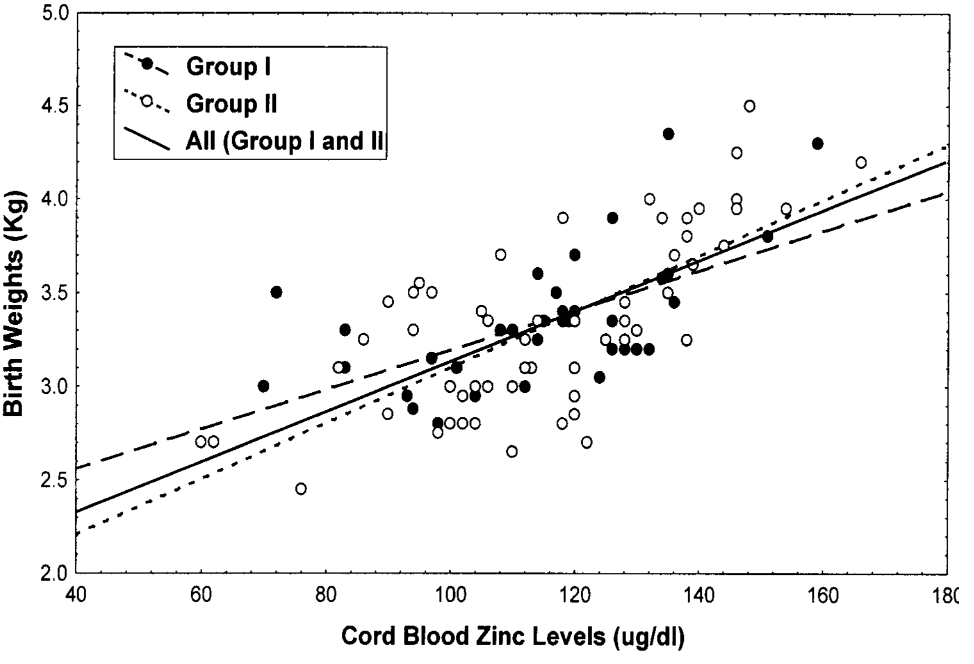

Fig. 1. Scatterplot of cord blood zinc levels versus neonatal birth weights. Groups I and II refer to mothers with Hb values less than 11.0 g/dL at term and to mothers with Hb values equal to or greater than 11.0 g/dL at term, respectively. Solid and open circles represent cord blood zinc levels versus neonatal birth weights in groups I and II, respectively.

minerals. Deficiency or decreased levels of various minerals and trace elements, such as iron, zinc, and copper, have been shown to be associated with many complications related to pregnancy outcome [1,6].

Findings pertaining to serum levels of zinc and copper in both maternal and cord blood observed in this study were in close agreement with results reported by others [17–21]. The reduction in maternal zinc levels observed during the third trimester is attributed to several factors, such as increased zinc uptake by the fetus and placenta, increased transfer of plasma zinc to maternal erythrocytes, expanded plasma volume, and decreased serum albumin availability for zinc binding during preg-

TABLE II. Hemoglobin, Trace Elements, and Neonatal Birth Weight in Anemic and Nonanemic Pregnant Women at Third Trimester

	Group I (Hb < 11.0 g/dL) (n = 36)		Group II (Hb ≥ 11.0 g/dL) (n = 56)	
	Third trimester	Cord blood	Third trimester	Cord blood
Hb (g/dL)	10.2 ± 0.6	15.1 ± 2.0	12.2 ± 1.2	15.8 ± 2.3
Fe (μg/dL)	67 ± 19	141 ± 17	80 ± 22	142 ± 13
Zn (μg/dL)	65 ± 11	111 ± 24	72 ± 8	113 ± 23
Cu (μg/dL)	230 ± 33	48 ± 20	234 ± 38	46 ± 16
Birth weight (kg)		3.322 ± 0.43		3.371 ± 0.46

nancy [20]. Furthermore, zinc transporters, such as ZnT, that are localized in placenta [22] may play an important role in accelerating zinc uptake from the mother's blood to the developing fetus. Thus, the level of zinc would be expected to be higher in cord blood than that in maternal blood. The observed higher levels of copper in maternal blood than that in cord blood may be caused by increased mobilization of stored copper in tissues, especially the liver, for its use by the developing fetus. Additionally, the concentration of ceruloplasmin, which is a major copper-binding protein, increases during pregnancy, and its level in maternal blood is much greater than that in cord blood [21,23]. Therefore, the expected difference between serum copper levels of the mother and fetus could be attributed to the much higher concentration of ceruloplasmin in the maternal serum.

Correlations between maternal zinc levels and neonatal birth weight were among the most commonly studied parameters for the evaluation of birth outcome [24]. Whereas some previous investigators observed positive correlations [25,26], results reported by this study and by others [27–29] could not find any correlation. However, the only positive correlation that was observed in this study is between serum zinc levels of cord blood and birth weight ($P < 0.001$), which is consistent with results reported by others [25,26,29]. This correlation might be considered a better indicator for the adequacy of zinc for fetal growth and development, because physiologic and metabolic factors that influence maternal zinc levels are not active in the fetus blood.

Results of this study demonstrate that the status of serum iron in maternal and cord blood are in close agreement with previous reports [30–32]; the levels were not altered significantly during pregnancy and no correlation with birth weight was observed. Despite the fact that serum iron levels below 50 μg/dL were observed in 28 (30%) of pregnant women studied during their third trimester; none of them suffered from any complications or symptoms related to iron deficiency, and their birth outcome was normal. Additionally, the mean serum iron levels in cord blood were significantly higher than that of the corresponding maternal blood levels even in mothers having iron levels less than 50 μg/dL. Similar results have been observed by other investigators [33–35]. The high serum iron in cord blood compared with maternal blood, even in anemic mothers (iron less than 50 μg/dL), suggests that the process of active transfer of iron from the mother to the fetus is adequately maintained.

The most commonly used method for the assessment of anemia during pregnancy is the measurement of Hb concentration [36–38]. According to World Health Organization recommendations, anemia in pregnant women is likely to be present when the Hb concentration is below 11.0 g/dL, and severe anemia is recognized when the Hb values are less than 7.0 g/dL [2,3,39]. The correlation between maternal Hb levels and birth weight is also conflicting [36–38,40]; some investigators reported higher infant's birth weight in association with higher maternal Hb levels, others reported higher birth weight in association with lower maternal Hb concentration, whereas others reported no significant association [40,41]. Results of this study demonstrate no significant association of either cord blood or maternal Hb levels with birth weight. Of the 36 anemic pregnant women observed at the third trimester (group I), only 7 (19%) had Hb levels between 9.0 and 10.0 g/dL, one (3%) had Hb value less than 9.0 g/dL, and none had Hb values below 7.0 g/dL. None of these women suffered from any complications during pregnancy and none delivered infants of low birth weight. The observed lower values of maternal iron and zinc, in addition to Hb concentration in group I, probably reflects a larger expansion of maternal plasma volume that usually occurs at the third trimester. A significant association between zinc levels of cord blood and birth weight was observed in both groups, indicating that the low maternal hemoglobin levels or the anemia observed during the third trimester has no effect on the adequacy of zinc available for fetal growth and development.

In conclusion, our results are consistent with previous reports and showed that maternal and neonatal serum levels of zinc, copper and iron were adequate in the studied group of healthy Jordanian pregnant women. The mild anemia observed in some of the pregnant women included in this study had no significant effect on maternal or cord blood parameters or neonatal birth weight. The observed significant correlation between neonatal serum zinc levels and birth weight in both normal and anemic mothers reflects the adequacy of zinc during pregnancy.

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