Original Article

The Assessment of Neonatal Anthropometric Indices Association with Umbilical Cord Blood Zinc and Magnesium Levels

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Abstract

Background: The present research aims to find the association between neonatal anthropometric parameters and zinc and magnesium concentration in cord blood.

Materials and Methods: The current cross-sectional report is a sub-study from the "PERSIAN Birth Cohort Study" conducted on 112 pairs of mother-neonate referring to the index hospitals for giving birth to their children during 2018–19. Umbilical cord blood was collected at delivery for the measurement of zinc and magnesium. Anthropometric indices were measured in standard protocols. Validated questionnaires were used for maternal diet in different trimesters. Dietary patterns were acquired based on exploratory factor analysis.

Results: The birth weight was reversely correlated with zinc concentration ($r = -0.249$, P-value = 0.008); however, the other anthropometric parameters did not show any association with zinc levels (P-value > 0.05). Similar evaluations for magnesium revealed no association between any of the anthropometric indices and this micronutrient agent (P-value > 0.05). Further evaluations represented insignificant differences in both zinc (P-value = 0.51) and magnesium levels (P-value = 0.49) between those with normal versus low birth weight. There was a negative association between the Western dietary pattern in the first trimester of pregnancy and cord blood zinc concentration (β (SE) = -0.21 (0.10); $P = 0.026$); while healthy and traditional dietary patterns in second and third trimesters were positively related to cord zinc concentration (all $P < 0.05$).

Conclusion: This research did not document a positive statistical association of cord blood zinc and magnesium with birth weight. The association of maternal Western dietary patterns with lower cord blood zinc levels highlights the importance of healthy nutritional habits in pregnancy.

Keywords: Birth weight, dietary pattern, magnesium, zinc

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Submitted: 07-Mar-2023; **Revised:** 15-Jul-2023; **Accepted:** 15-Jul-2023; **Published:** 29-Nov-2023

Introduction

The trend of intrapartum growth has a crucial position in the future growth and development of newborns. The importance of the issue becomes clear due to the rapid cellular turnover in fetal and maternal growth and cell differentiation.[1] Given that, they both are susceptible to dietary deficiencies, particularly for essential micronutrients, such as zinc and magnesium.[2]

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Quick Response Code:

Website: www.advbiores.net

DOI: 10.4103/abr.abr_90_23

Zinc is an element with critical roles in cellular processes including transcription, gene expression, cellular division, growth, and differentiation.[2] It has been claimed that maternal zinc deficiency in the period of pregnancy might potentially lead to poor fetal growth and low birth weight (LBW);[3] however, the data in this regard are inconclusive.[4]

How to cite this article: Amini N, Mousavi S, Vard B, Daniali SS, Kelishadi R. The assessment of neonatal anthropometric indices association with umbilical cord blood zinc and magnesium levels. Adv Biomed Res 2023;12:253.

The latter, magnesium, is one of the remarkable intracellular cations involved in numerous physiological functions including protein synthesis, preserving membrane integrity, neural messages conduction, muscle contraction, and hormonal regulation.[2] Given that, magnesium deficiency might potentially tend to significant growth and development disturbances for the fetuses.[2]

The fetus' growth is determined by using anthropometric measurements, including weight, length, and head circumference, which are known as proxy markers of well-being in the fetus during intrauterine growth.

The intake of required nutrients including micronutrients such as zinc and magnesium is steeply dependent on the maternal dietary pattern which significantly affects intrauterine fetal growth and pregnancy outcomes as well as further growth and development during infancy.[5-8] It has been well-elucidated that a dietary pattern containing green and leafy vegetables, colored vegetables, fruits, nuts, low-fat dairy, chicken, flesh bulky vegetables, egg, and unsaturated fat accompanies a lower risk of pregnancy adverse outcomes and better fetal growth.[6,8] Moreover, a healthy dietary habit can provide the mothers with sufficient micronutrients.[9]

Anthropometric indices including body weight, height, and head circumference are applied as the means to determine growth patterns in newborns. Accordingly, the current study is aimed to assess the association of anthropometric indices as the parameters associated with the newborns' growth with the level of zinc and magnesium in the blood drawn from the umbilical cord.

Materials and Methods

The current cross-sectional investigation is a sub-study of the "PERSIAN Birth Cohort Study" conducted on 112 pairs of mothers and newborns from January 2018 to February 2019. Accordingly, those mothers who gave birth to their children at Shahid Beheshti, Al-Zahra, and Zahraye Marzieh hospitals entered into the study. The protocol of the study has been previously published.[10]

The study protocol that met the Helsinki Declaration criteria was suggested to the Ethics Committee of Isfahan University of Medical Science and approved via code number (IR.MUI.MED.REC.1398.692). Iranian pregnant women without any previous history of infertility who lived for a minimum period of a year in this metropolitan gave childbirth in the hospitals of Isfahan and were willing to participate in the current study considering the necessity of blood drawn from the umbilical vein were included. The exclusion criteria were determined as the presence of major risks of small for gestational age (SGA) and intrauterine growth retardation (IUGR), or the previous history of giving birth to SGA or IUGR, stillbirth or preterm labor (before 37 gestational weeks) and the history of serious medical complications. The study was explained to the legal guardians of the newborns. They were reassured about the protecting privacy of data and they were satisfied to participate in the study.

Accordingly, eight individuals without eligibility criteria were excluded from the study, and 112 were considered for final analysis.

The newborns were primarily examined at the time of birth to evaluate their general health and probable congenital anomalies. Moreover, a pediatric assistant measured the anthropometric indices including neonates' weight, height, and head circumference by the standard protocols and scales were measured, and recorded in the children's development card.

Birth weight was measured using a standard scale with the utmost accuracy of measuring 1 gram. The newborns were categorized into three groups of ≤2500 g, 2500–4000 g, and >4000 g as LBW, normal birth weight (NBW), and macrosomia, respectively.[11]

The head circumference was measured from the glabella to the posterior external protuberance using a meter with 1-millimeter accuracy.

Height was determined as the distance from the vertex to the heel in a supine-positioned newborn using a similar meter.

Umbilical cord blood samples (2 cc) were drawn at the time of delivery, after centrifuging the samples, serums were kept in a freezer at -70 degrees, and sent to a referral medical laboratory to measure zinc and magnesium levels, by atomic absorption spectrophotometry using a Hitachi 911 device and reported as microgram/dl.

Data on food intake and dietary supplements during each trimester of pregnancy were obtained using a validated food frequency questionnaire.[12] Food grouping in dietary patterns was conducted based on the study conducted by Hajianfar *et al*. subgrouping the subjects into three categories of healthy, traditional, and Western dietary patterns.[6] Moreover, information about indoor household air pollutants including smoking (cigarette and hookah), was collected through self-report questionnaires.

Exploratory factor analysis (EFA) was performed to extract latent constructs for dietary patterns at baseline (before pregnancy) and structural equation model (SEM) used to assess the direct relationship between dietary patterns and birth outcomes, and the indirect association mediated via magnesium and zinc. In the measurement part of the model, latent variables (ovals) were linked to related observed variables (rectangles). Structural equation model was performed separately for each trimester and mediator. Appropriate SEMs were generated with R-free statistical software (version 3.3) and model parameters were estimated using maximum likelihood methods. Model fit was assessed using the Tucker-Lewis coefficient (TLI), comparative fit index (CFI), and root-mean-square error (RMSE) indices.

Satisfactory model fit was indicated by RMSE values below 0.10, and TLI and CFI values above 0.8.

Statistical analysis

Data were analyzed using the Social Science Statistical Package software (IBM® SPSS® Statistics, Chicago) version 22. Quantitative variables are shown as mean and standard deviation, or median (interquartile range), and qualitative variables are presented as numbers (percentages). Correlation and multivariate linear regression modeling are used to determine relationships between quantitative variables. The regression model included potential confounders such as maternal age, infant sex, birth order, education level, income level, maternal weight gain during pregnancy, and smoking. *P*-values less than 0.05 were considered statistically significant.

Results

A total of 112 mother–infant pairs were included in this study. The mother's mean age (SD) was 30 (4.88) years. Mean levels of zinc and magnesium in cord blood were 10.52 (2.60) μg/L and 52.09 (6.43) μg/L, respectively. Detailed characteristics of mothers and neonates are shown in Table 1.

As illustrated result in Table 2, after sensitive analysis, the birth weight was negatively correlated with zinc levels (r = -0.249, *P*-value = 0.008); however, the other anthropometric parameters did not show any association with zinc levels (*P*-value > 0.05). Similar evaluations for magnesium revealed no association between any of the anthropometric indices and this micronutrient agent (*P*-value > 0.05).

Table 1: Baseline characteristics of mothers and neonates

Variables	Mean±SD or Frequency (%)	SD or %
Sex (male)	51 (45.5)	45.5
Birth Weight (g)	3122.15±490.08	490.08
Length (cm)	50.55	2.88
Head circumference (cm)	34.84	3.16
Zinc (μg/l,)	10.52	2.60
Magnesium (μg/l,)	52.09	6.43
Gestational age (week)	38.56	1.83
Maternal age (years)	30.01	4.88
Primary or secondary smoker	16 (14.28)	14.28
Maternal weight gain (Kg)	12.03	3.34
Maternal body mass index (kg/m^2)	26.43	4.39

Table 2: Correlation between zinc and magnesium levels and anthropometric indices of the neonates

Parameter	Correlation coefficient		*P*	
	zinc	magnesium	zinc	magnesium
Birth weight	-0.249	-0.131	0.008	0.16
Length	-0.093	0.014	0.33	0.88
Head circumference	-0.096	0.062	0.31	0.51

Further evaluations in Table 3 represented insignificant differences in both zinc (*P*-value = 0.51) and magnesium levels (*P*-value = 0.49) between those with NBW versus LBW. The cord blood concentration of zinc was lower in macrosomia neonates compared to the other weight groups [Table 3].

Different dietary patterns were acquired based on EFA. As shown in Table 4, bivariate correlation analysis showed an association between dietary patterns at baseline and in three trimesters with cord blood zinc and magnesium levels. There was a negative association between the Western dietary pattern in the first trimester of pregnancy with cord blood zinc level (β (SE) = -0.21 (0.10); P = 0.026); while healthy and traditional dietary patterns in second and third trimesters were positively correlated with cord zinc levels (all $P < 0.05$). Maternal dietary patterns were not associated with cord blood magnesium levels.

Discussion

The current research aimed to evaluate the association of micronutrients such as zinc and magnesium levels in the umbilical cord with the birth-time anthropometric parameters in newborns as well as maternal dietary patterns. Given that, we found no association between cord blood zinc and magnesium concentrations, and neonatal anthropometric indices at birth. Moreover, the Western dietary pattern in the first trimester of pregnancy was negatively associated with cord blood zinc level, while the other two assessed patterns, traditional and healthy, affected the cord blood zinc level positively. Nevertheless, we found an association between magnesium levels neither with the newborns' anthropometric parameters nor the maternal dietary habits.

In the current study, the mean of cord blood zinc was not different between LBW and NBW neonates, although the mean cord blood zinc level was lower among macrosomia neonates in comparison to other weight groups. As only four of the newborns had macrosomia, this significant statistical association does not seem to have clinical implications.

Surfing the literature revealed inconsistent outcomes regarding the association of at-birth anthropometric indices with micronutrient concentrations. In agreement with our findings, Mohamed and colleagues represented no correlation between body birth weight and micronutrients including zinc and magnesium concentrations.[1] Similar results were concluded in the study of Parizadeh *et al*.,[2] Ugwuj*a et al*.,[4] and Daniali *et al*.[13] Contrarily, another study, presented a weak positive correlation between zinc levels and birth weight,[14] while a meta-analysis by Akdas *et al*. pointed out that low levels of maternal zinc, but not neonatal was associated with an increased risk of LBW.[15] These differences might reflect the impact of drawn blood samples to measure zinc levels on the outcomes as it has been presented that the concentration of cord blood zinc is lower than that of the maternal blood.[16]

Table 3: Comparison of the mean Zinc and Mg levels according to the neonate weight level

Parameter	Study population (*n*=112)			*P*	*P* (<2500 vs. 2500–4000)
	<2500 (*n*=10)	2500 ≤4000 (*n*=106)	≥4000 (*n*=4)		
Zinc level (microgram/dl)	10.56±2.63	10.52±2.58	8.12±2.60	0.007	0.51
Magnesium level (microgram/dl)	52.30±6.46	52.34±6.36	48.10±4.65	0.363	0.49

Table 4: Correlation between maternal dietary patterns in baseline and three trimesters with zinc and magnesium levels

	Dietary patterns	Magnesium		Zinc B (SE)	*P*
		B (SE)	*P*		
Baseline	Healthy	-1.85 (3.51)	0.598	-0.007 (0.07)	0.919
	Traditional	-0.30 (0.33)	0.366	-1.98 (11.67)	0.865
	Western	-0.36 (0.22)	0.099	-0.05 (0.08)	0.58
First trimester	Healthy	-0.07 (0.14)	0.602	0.08 (0.06)	0.141
	Traditional	-0.04 (0.14)	0.768	0.08 (0.06)	0.20
	Western	-0.20 (0.24)	0.398	-0.21 (0.10)	0.026
Second trimester	Healthy	-0.07 (0.08)	0.384	0.11 (0.04)	0.003
	Traditional	-0.08 (0.11)	0.456	0.15 (0.05)	0.002
	Western	0.19 (0.66)	0.768	-0.10 (0.27)	0.703
Third trimester	Healthy	-0.04 (0.11)	0.75	0.13 (0.05)	0.007
	Traditional	-0.001 (0.07)	0.989	0.11 (0.03)	<0.001

Adjusted for Zn and Mg levels, mother age and body mass index and neonate weight for gestational age in the path analysis

The finding regarding magnesium is in line with some of the previous studies stating no association between umbilical cord blood magnesium with birth weight.[17] However, other studies have pointed to the elevated risk of adverse pregnancy outcomes including intrauterine growth retardation, preterm labor, preeclampsia in the presence of magnesium deficiency.[18,19] These discrepancies might have occurred due to the diversity of contributing factors to fetal growth or different techniques of micronutrient measurements.

Overall, despite the positive view in correspondence to the association of normal levels of micronutrients including zinc and magnesium for the prevention of adverse pregnancy outcomes,[20,21] there is no consistent study supporting the idea to administer supplementations for pregnant women to prevent LBW.[22,23]

In the present study, the Western dietary pattern in the first trimester of pregnancy was related to decreased cord blood zinc levels, whereas the healthy and traditional dietary patterns in the second and third trimesters of pregnancy were related to higher cord blood zinc levels. This finding is in agreement with Paula *et al*.s' study that presented lower cord blood zinc and other micronutrients in pregnant mothers who had a Western dietary pattern with high consumption of fast foods.[24] A hypothesis has been raised that the Western dietary pattern contains low levels of zinc supplies leading to inadequate zinc stores in the maternal body to be transmitted to the fetus. Accordingly, it is suggested that improving maternal nutritional status in the peri-conceptional period and during the pregnancy may be useful for the health promotion of their children.[25] In this regard, Grieger *et al*. detected that a protein-rich dietary pattern in pregnant women might improve the perinatal outcomes and reduce the probability of preterm delivery and neonates with shorter birth heights.[26]

In the current study, smoking was considered as cofounder and its association with other variables was not significant. It is shown that zinc is trapped in the placenta of smoker women, and in turn, it may result in reduced fetal zinc transfer and impaired fetal growth.[14] A study on the effect of smoking on newborns' body size at birth found that maternal smoking was associated with abnormal and reduced length and head circumference of neonates.[27] However, in our study, smoking was considered as cofounder and its association with anthropometric indices was not significant.

The main limitation of the present study is its cross-sectional design, so cause-effects cannot be assessed. Moreover, we used self-reported data on dietary habits and other lifestyle factors. The main strength of our study is its novelty in the Iranian population and considering the dietary habits in all trimesters of pregnancy.

Conclusion

Micronutrients, including zinc and magnesium, have several beneficial effects on pregnant women and their fetuses. However, the current study did not document a significant association of these micronutrients with birth weight. This finding is suggested to be because zinc and magnesium deficiency was not frequent in mothers. Moreover, several other factors can potentially influence fetal growth and birth weight. Our finding on the association of maternal Western dietary patterns with lower cord blood zinc levels highlights the importance of healthy dietary habits in pregnant women. Further, more prospective longitudinal studies involving large samples are required to assess the clinical impacts of the current findings.

Acknowledgment

This study was funded by the Isfahan University of Medical Sciences, Isfahan, Iran (IR.MUI.MED.REC.1398.692). It was a sub-study of the PERSIAN Birth Cohort, project 194354 (IR.MUI.REC.1394.1.354) funded by the Ministry of Health and Medical Education.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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