Journal of Shahrekord University of Medical Sciences
doi:10.15171/jsums.2019.41 2019;21(5):237-243 http://j.skums.ac.ir

Original Article

The relationship of serum vitamin D, calcium, and phosphorus levels of mothers with growth indices of their newborns in pregnant women admitted to Hajar hospital of Shahrekord in 2016

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Abstract

Background and aims: Vitamin D deficiency is a known pandemic problem which has thousands of bad health outcomes. The aim of the current study was to investigate the effect of maternal vitamin D, Ca, and PO4 levels on growth indexes of newborns at birth and 1 month and 3 months after delivery in pregnant women admitted to Hajar hospital of Shahrekord, Iran in 2016.

Materials and Methods: This descriptive-analytical study was conducted on 196 pregnant women admitted to the hospital. During pregnancy, 5 mL of mother's blood and 5 mL of umbilical cord blood were taken. Serum calcium and phosphorus levels were determined immediately after sampling and then centrifuged. After collecting the samples, 25-OHD levels were measured by ELISA method. Neonatal growth indexes such as weight, height, and head circumference atbirth,1 month, and 3 months were measured. Data were analyzed using independent samples *t* test, ANOVA, and correlation coefficient by SPSS version 16.0.

Results: Deficiency of vitamin D, phosphorus, and calcium was observed in 76%, 1%, and 25% of women, respectively. Moreover, deficiency of vitamin D, phosphorus, and calcium was reportedin56.1%, 15.8%, and 9.2% of newborns, respectively. There was a significant relationship between calcium level in newborns and their weight and height at birth, one month, and three months of age ($P<0.05$). Levels of vitamin D, calcium and phosphorus of mother and newborns were significantly correlated ($P<0.05$).

Conclusion: More than two-thirds of mothers and more than half of the newborns were deficient in vitamin D. There was also a lack of calcium in one third of mothers and 9.2% of newborns, and phosphorus deficiency was observed only in 1% of mothers and 15.8% of newborns. Due to the low intake of these materials through nutrition, the supplementation of these substances, especially vitamin D and calcium, is required during pregnancy.

Keywords: Vitamin D, Calcium, Phosphorus, Biometry, Newborn

Received: 22 May 2019, Accepted: 20 July 2019, ePublished: 30 October 2019

Introduction

Deficiency of Vitamin D is a known pandemic problem which has thousands of unpleasant health outcomes (1). Vitamin D is a vital fat-soluble vitamin which plays a key role in the metabolism of calcium in children and adults (2). The serum level of vitamin D varies based on the dietary intake, skin pigmentation, obesity, seasons and geographical location, and type of clothing (3, 4).

Exposure to sunlight is the main factor affecting the concentration of vitamin D in the mother (5). When the skin is exposed to UV rays of the sun, it naturally produces vitamin D. However, there is a relationship between exposure to sunlight and skin cancer. As a result, the APP and the American Academy of Dermatology have recommended that children under six months of age not be exposed to sunlight and that all age groups use UV-protecting sunscreens and protective clothing. Regarding this issue, the International Association of Endocrinology recommended vitamin D prophylaxis of 400 U/day for infants and 600-2000 U/day for pregnant women (6). Severe vitamin D deficiencies during pregnancy can delay intrauterine growth, and the effects of this deficiency on osteoporosis have also been reported in some studies (7, 8). Long-term effects of maternal vitamin D deficiency

include skeletal diseases, increased risk of autoimmune diseases, cancers, type 1 and type 2 diabetes, cardiovascular diseases, infectious diseases, skin problems, schizophrenia, cancer, depression, MS, insufficient development of enamel, asthma, and atopy (9). Vitamin D deficiency among pregnant women is not specific to a particular ethnic group or region and the lack of it is widespread in the world. Such a large shortage undoubtedly has harmful effects on the health of pregnant women and their infants (10,11).

During embryonic development, vitamin D metabolism is similar to that of adults, but the source of this vitamin in the fetus and newborn baby will depend on the storage of maternal vitamin D. In such a situation, maternal vitamin D deficiency causes the fetus to be exposed to vitamin deficiency during development (12). The two elements of calcium and phosphorus constitute 65% of human adult bone mass. Although most of the calcium in the body is deposited in the bones, low levels of this element are present in intracellular and extracellular fluids and take part in important processes of electrical flow of cells and blood coagulation.

Phosphorus is an element that is used as a supplement to calcium in the bone. It also plays a role in important processes such as energy production in cells. Vitamin D is required to absorb these two vital elements from diet. These elements are important for healthy bones. The minimum calcium requirement is 450 mg, and 800 mg is required in adults. However, 1200 mg is recommended during pregnancy and lactation. Complications of calcium deficiency in children, youth, and adults are rickets, osteomalacia, and osteoporosis, respectively (4). In the event of severe calcium deficiency, severe muscle contraction occurs. Calcium is a factor in bone strength, and adequate calcium should be consumed in the pre-puberty period to have appropriate bone density. Considering the global spread and high prevalence of vitamin D as well as calcium deficiency and its important role in fetal development and maternal and child health, and considering the fact that serum levels of vitamin D, calcium, and phosphorus depend on feeding, type of clothing and geographical location, the investigation of these elements in pregnant women and their infants is of great importance. There is also no information available on the status of vitamin D, calcium, and phosphorus in women of reproductive age in Chaharmahal and Bakhtiari province, but it seems that vitamin D, calcium, and phosphorus deficiency is also common there, like other physiological groups in other parts of the country. The aim of this study was to determine the prevalence of vitamin D, calcium, and phosphorus deficiency in pregnant women referred to Hajar hospital. Moreover, we tried to investigate the relationship of maternal serum vitamin D, calcium, and phosphorus levels with vitamin D, calcium, and phosphorus levels in umbilical cord blood. Additionally, we tried to compare the infant growth factors including weight, height, and head circumference in terms of levels of vitamin D, calcium, and phosphorus in mothers and newborns.

Materials and Methods

This descriptive-analytical study was performed on pregnant women referred to Hajar hospital.

A total of 196 pregnant women were admitted to the hospital. The pregnant women and newborns at birth, 1 month, and 3 months of age were included in the study. The infants over 3 months of age and those who consumed oral drops were excluded. 5 cc of the mother's blood and 5 cc of umbilical cord were taken in the pregnancy term. Serum calcium and phosphorus levels were determined immediately after sampling and centrifugation, and the

Table 1. Vitamin D, phosphorus, calcium levels of mothers and infants, and growth indices

Variable		Minimum	Maximum	Mean ± SD
Mother	Vitamin D level (ng/mL)	1	87	16.71 ± 17.70
	Calcium (mg/dL)	7	10	8.60 ± 0.42
	Phosphorus (mg/dL)	1	6.7	2.86 ± 1.46
Infant	Vitamin D level (ng/mL)	1	82	19.88 ± 20.32
	Calcium (mg/dL)	8	11.10	9.85 ± 0.64
	Phosphorus (mg/dL)	1	10.60	2.88 ± 2.21
Weight (g)	Birth	1700	4155	3164.2 ± 435.18
	One month	2200	5150	3800.05 ± 451.70
	Three months	3800	6900	5664.18 ± 440.26
Height (cm)	Birth	36	54	49.43 ± 2.30
	One month	39	59	52.87 ± 2.73
	Three months	46	64	59.79 ± 2.78
Head circumference (cm)	Birth	31	52	35.10 ± 1.88
	One month	32	54	37.10 ± 1.92
	Three months	37	60	41.35 ± 2.42

serum was isolated and stored at -20°C. After collecting the samples, the amount of 25-hydroxyvitamin D was measured by ELISA method. The infant growth indices including weight, height, and head circumference were measured at birth, 1 month, and 3 months of age. In this study, 25-hydroxyvitamin D level higher than 70 nmol/L was considered normal and values lower than 70 nmol/L were considered deficient in vitamin D levels.

Data were presented as means ± SD for continuity and frequency with percentage for categorical variables. Independent samples *t*-test and analysis of variance (ANOVA) test were used for comparing variables between groups. Pearson correlation coefficient was calculated for evaluating relationships among the variables. Statistical analysis was done by SPSS version 16.0 and *P* values less than 0.05 were determined statistically significant.

Results

Totally, data of 196 mothers and infants were evaluated for vitamin D, calcium, and phosphorus levels, as well as infant growth indices including weight, height, and head circumference at birth, one month, and three months of age.

The mean age of mothers was 27.50 ± 4.7 years, ranging from 18 to 35 years old. The values of measured maternal and infant indices are presented in Table 1. According to this table, the mean vitamin D levels in mothers and infants were 16.71 ± 17.70 ng/mL and 19.88 ± 20.32 ng/mL, respectively. The mean phosphorus levels in mothers and infants were 2.86 ± 1.46 mg/dL and 2.88 ± 2.21 mg/dL, respectively. The mean calcium levels in mothers and infants were 8.60 ± 0.42 mg/dL and 9.85 ± 0.64 mg/dL, respectively.

In this study,78.6% of mothers had vitamin D levels less than 21 ng/mL (deficiency), 5.1% of mothers had vitamin D levels between 21 and 30 ng/mL (on average), and 16.3% of mothers had levels higher than 30 ng/mL(normal). In addition, 56.1% of the infants had vitamin D level lower than 15 ng/mL (deficiency), 13.3% of them had levels between 15 and 20 ng/mL(average), and 30.6% had levels higher than 20 ng/mL(normal).

Concerning the lack of phosphorus in mothers and infants, 1% of mothers and 15.8% of newborns were deficient in phosphorus. In addition, considering calcium deficiency, 25% of mothers and 9.2% of newborns were deficient in calcium (Table 2).

The infants' mean weights at birth, at 1 month, and at 3 months of age were 3164.2 ± 435.18 g, 3800.05 ± 451.70 g, and 5664.18 ± 440.26 g, respectively. The mean heights of infants at birth, at 1 month, and at 3 months of age were 49.43 ± 2.30 cm, 52.87 ± 2.73 cm, and 59.79 ± 2.78 cm, respectively, and their means of head circumference at birth, at one month, and at three months of age were 35.10 ± 1.88 cm, 37.10 ± 1.92 cm, and 41.35 ± 2.42 cm, respectively (Table 1).

In this study, 7.7% (15 babies) of neonates at birth had a weight less than 2500 g. Based on the findings presented in Table 2, no growth factors were affected by vitamin D and calcium levels in both mothers and infants. However, the low level of maternal phosphorus was significantly associated with gaining weight at birth, one month, and at three months of age (P = 0.003, P = 0.016, and P = 0.002), as well as with the infants' heights at birth and one month of age) (P = 0.012 and P = 0.031), respectively. The results of the correlation between vitamin D, phosphorus, calcium of mothers and infants, and growth parameters of infants are presented in Table 3. The results presented in Table 3 show that there has been a direct and significant correlation between vitamin D levels of mothers and infants (P = 0.001, r = 0.714), calcium levels of mothers and infants (P = 0.001, r = 380), and phosphorus levels of mothers and infants (P = 0.001, r = 0.333). However, based on the findings, calcium levels of mothers had a significant inverse correlation with the phosphorus levels of infants (P = 0.025, r = -0.160).

The results presented in Table 3 show that the calcium levels of infants had a direct and significant correlation with weight at birth (P = 0.007, r = 1.192), at one month of age (P = 0.005, r = 0.202), with height at birth (P = 0.009, r = 0.186), and with height at three months of age (P = 0.001, r = 0.0227).

The vitamin D level of infants has an inverse and significant correlation with head circumference at 3 months of their age (P = 0.039, r = -0.148).

The findings of this study (Table 3) showed that there was no significant correlation between vitamin D level of infants and neonatal growth indices except for head circumference at three months of age. The *P* values and correlation coefficients for each of the variables were as follows: weight at birth (P = -0.310, r = 0.073), weight at 1 month of age (P = 0.207, r = -0.090), weight at 3 months of age (P = 0.453, r = 0.053), height at birth (P = 0.565, r = 0.041), height atone month of age (*P* = 0.643, r = 0.033), height at 3 months of age (P = 0.440, r = 0.055), head circumference at birth (P = 0.066, r = 0.132), head circumference at one month of age (P = 0.085, r = 0.123), and head circumference at 3 months of age (P = 0.148, r = 0.039). Additionally, there was no significant relationship between vitamin D, phosphorus, and calcium levels of mothers and infants' growth indices (Table 2).

Discussion

Based on the results of this study, 78.6%, 1%, and 25%of pregnant women had deficiency in vitamin D, phosphorus, and calcium. Moreover, deficiencies of vitamin D, phosphorus, and calcium were observed in 56.1%, 15.8%, and 9.2% of the infants, respectively. In this study, no significant correlation was found between vitamin D, phosphorus, and calcium levels of mothers and infants' growth indices. However, the infants' calcium level had a

Table 2. The mean (±SD) of growth indices of infants at birth, 1 month, and 3 months based on vitamin D, phosphorus, calcium levels in mothers and infants

Variable	Level	Number	Percent	Weight (g)			Height (cm)			Circumference (cm)		
				Birth	1 month	3 months	Birth	1 month	3 months	Birth	1 month	3 months
Vitamin D level of mother	< 21 ng/mL(deficiency)	154	78.6	3168 ± 445	3805 ± 461	5647 ± 463	49.4 ± 2.4	52.8 ± 2.9	59.8 ± 2.8	35.1 ± 1.96	37.1 ± 2.02	41.4 ± 2.6
	21-30 ng/mL (average)	10	5.1	3090 ± 203	3740 ± 214	5600 ± 269	49.4 ± 1.1	53 ± 1	58.3 ± 4.5	34.4 ± 1.4	36.4 ± 1.4	40.55 ± 1.4
	> 30 ng/mL (normal)	32	16.3	3170 ± 444	3796± 467	5647 ± 463	49.7 ± 2	52.9 ± 1.9	60.2 ± 2	32.3 ± 1.55	37.3 ± 1.5	41.4 ± 1.6
	P value	-	-	0.816	0.916	0.328	0.942	0.991	0.158	0.432	0.437	0.560
Vitamin D level of infant	< 15 ng/mL (deficiency)	110	56.1	3209 ± 394	3848 ± 396	5712 ± 439	49.5 ± 2.4	52.9 ± 3.1	59. 8 ± 2.9	35.4 ± 2.1	37.4 ± 2.16	41.6 ± 2.8
	15-20 ng/mL (average)	26	13.3	3151 ± 415	3838 ± 464	5632 ± 376	49.6 ± 1.5	53.3 ± 1.6	60.2 ± 1.7	34.8 ± 1.4	36.9 ± 1.3	41.5 ± 2.5
	> 20 ng/mL(normal)	30	30.6	3085 ± 504	3695 ± 517	5589 ± 461	49.2 ± 2. 5	52.6 ± 2.5	59.6 ± 3	34.7 ± 1.5	36.7 ± 1.6	40.8 ± 1.6
	P value	-	-	0.211	0.104	0.213	0.573	0.578	0.650	0.064	0.080	0.109
Mother calcium level	< 8.4 ng/mL (deficiency)	49	25	3203 ± 343	3846 ± 321	5723 ± 328	49.6 ± 1.4	53.1 ± 1.5	60.2 ± 1.5	35.3 ± 1.4	37.5 ± 1.5	41.9 ± 3
	8.4-10.2 mg/dL (normal)	147	75	3151 ± 461	3784 ± 487	5644 ± 471	49.4 ± 2.5	52.8 ± 3	59.7 ± 3.1	35± 2	37 ± 2	41.16 ± 2.2
	P value	-	-	0.456	0.373	0.262	0.555	0.455	0.216	0.299	0.080	0.060
Infant calcium level	<15 ng/mL (deficiency)	18	9.2	3122 ± 417	3752 ± 426	5685 ± 385	49.6 ± 1.4	53± 1.5	59.1 ± 3.6	35.3 ± 1.7	37.7 ± 1.5	41.8 ± 1.5
	9-11.5 mg/dL (normal)	178	90.8	3168 ± 437	3804 ± 455	5661 ± 446	49.4 ± 2.4	52.9 ± 2.8	59.9 ± 2.7	35.09 ± 1.9	37.05 ± 2	41.3 ± 2.5
	P value	-	-	0.675	0.657	0.812	0.773	0.797	0.260	0.732	0.172	0.410
Mother phosphorus level	<15 ng/mL (deficiency)	2	1	4052 ± 144	4550 ± 353	6600 ± 212	53.5 ± 0.7	57 ± 0.7	63.5 ± 0.7	36.5 ± 0.7	38.5 ± 0.7	42.8 ± 0.4
	2.5-4.5 mg/dL (normal)	194	99	3153 ± 425	3789 ± 442	5652 ± 428	49.39 ± 2.3	52.82 ± 2.7	59.75 ± 2.8	35.1 ± 1.9	37.1 ± 1.9	41.6 ± 2.8
	P value			*0.003	*0.016	*0.002	*0.012	*0.031	0.057	0.293	0.303	0.415
Infant phosphorus level	< 15 ng/mL (deficiency)	31	15.8	3148 ± 553	3800 ± 562	5713 ± 555	49.5 ± 2. 6	52.9 ± 2.6	58.9 ± 4.4	35.1 ± 1.6	37.1 ± 1.6	41.3 ± 2.4
	4.5-6.52 mg/dL (normal)	165	84.2	3167 ± 411	3800 ± 429	5653 ± 416	49.4 ± 2.3	52.9 ± 2.8	60 ± 2.3	35.1 ± 1.9	37.1 ± 2	41.4 ± 2.6
	P value	-	-	0.767	0.854	0.515	0.962	0.970	*0.035	0.939	0.980	0.377

Table 3. Correlation coefficient between vitamin D, phosphorus and calcium levels of mothers and vitamin D, phosphorus and calcium levels of infants and growth indices of infant

Variable	Mother Vitamin D	Mother Calcium	Mother Phosphorus	Infant Vitamin D	Infant Calcium	Infant Phosphorus
Mother vitamin D	1					
Mother calcium	r=0.021 P=0.77	1				
Mother phosphorus	r=0.045 P=0.527	r=0.019 P=0.791	1			
Infant vitamin D	r=0.714 P=0.001	r=0.073 P=0.311	r=0.083 P=0.250	1		
Infant calcium	r=0.011 P=0.877	r=0.380 P=0.001	r= -0.128 P=0.073	r=0.108 P=0.134	1	
Infant phosphorus	r=0.025 P=0.729	r=-0.160 P=0.025	r=0.333 P=0.001	r=0.028 P=0.699	r=0.092 P=0.202	1
Weight at birth	r=0.007 P=0.921	r=0.030 P=0.679	r=0.026 P=0.722	r=-0.073 P=0.310	r=0.192 P=0.007	r=-0.042 P=0.556
Weight at one month	r=-0.005 P=0.948	r=0.026 P=0.719	r=0.026 P=0.697	r=-0.090 P=0.207	r=0.202 P=0.005	r=-0.034 P=0.638
Weight at three months	r=0.075 P=0.294	r=-0.043 P=0.546	r=-0.067 P=0.349	r=-0.053 P=0.453	r=0.103 P=0.154	r=-0.023 P=0.763
Height at birth	r=0.020 P=0.781	r=0.011 P=0.874	r=0.039 P=0.590	r=-0.041 P=0.565	r=0.186 P=0.009	r=-0.034 P=0.636
Height at one month	r=0.012 P=0.870	r=-0.038 P=0.593	r=-0.024 P=0.737	r=-0.033 P=0.643	r=0.135 P=0.060	r=0.003 P=0.972
Height at three months	r=0.030 P=0.672	r=-0.002 P=0.978	r=-0.113 P=0.115	r=0.055 P=0.440	r=0.227 P=0.001	r=0.050 P=0.489
Head circumference at birth	r=0.021 P=0.770	r=-0.057 P=0.427	r=0.038 P=0.595	r=-0.132 P=0.066	r=0.005 P=0.949	r=0.055 P=0.446
Head circumference at one month	r=0.014 P=0.841	r=-0.089 P=0.217	r=0.104 P=0.146	r=-0.123 P=0.085	r=-0.027 P=0.703	r=0.098 P=0.173
Head circumference at three months	r=0.025 P=0.730	r=-0.040 P=0.575	r=0.026 P=0.716	r=-0.148 P=0.039	r=-0.037 P=0.607	r=0.040 P=0.581

significant relationship with weight and height at birth, with weight after one month, and with height after three months of age.

In a study by Ergur et al, vitamin D deficiency was reported in 81.3% of mothers (severe deficiency in 27%and average deficiency in 54.3%). In another study conducted by Hatami et al (13), a high proportion of pregnant women had vitamin D deficiency. In other words, 9 in 10 pregnant women had serum vitamin D levels less than 30 ng/mL. In their study, the mean serum vitamin D level was 13.5 ng/mL, which was lower than our mean serum vitamin D level (16.71). In a study by Maghbooli et al, a high prevalence of vitamin D deficiency in both mothers and infants was reported. Almost 2 in 3 mothers had vitamin D deficiency, while only 1 in 10 newborns had normal vitamin D level (14). In their study, Weiler et al stated that more than half of mothers and more than one-third of infants had vitamin D deficiency (15).

Concerning the relationship between vitamin D level and growth indices of infants, Hatami et al and Maghbooli et al found no significant relationship between serum vitamin D levels and neonatal characteristics including head circumference, height, and weight at birth (13, 14), which was similar to our study. Other studies also confirmed that vitamin D level of pregnant women does not have any significant effect on the birth weight of infants (16-18). However, contrary to this conclusion, Thompson et al. in their study reported the beneficial effects of vitamin D on birth weight (19). Zinc serum level did not have any effect on the growth indices of infants, which can be due to not using supplementation. In this study, only the level of maternal vitamin D has been studied. It is likely that the use of high doses of vitamin D supplementation in pregnant mothers or the use of vitamin D supplementation as a mixture of micronutrients increases the growth indices of infants. The study conducted by Seddighi Looye et al showed that calcium deficiency was observed in 49.4% of mothers and 2.3% of newborns (20). In this study, there was a significant correlation between maternal calcium and low birth weight of infants, and therefore the infants of mothers with calcium deficiency had lower birth weight than the infants of other mothers. In a study by Sabour et

al, the mean vitamin D in mothers was 2.26 ± 1.87 mg/d and the mean calcium intake was 816.84 ± 370.48 mg/d. The infants of mothers with sufficient calcium and vitamin D had significantly higher birth weight than infants of mothers who received insufficient calcium and vitamin D intake. However, no significant correlation was found between the head circumference of infants with the calcium and vitamin D intake of mothers. The study showed that receiving enough calcium and vitamin D through food or supplements causes the weight gain of mother and fetus and more proper height and weight in the fetus. The use of nutrient-rich foods, especially dairy products, as well as enrichment of food sources and supplements could help people at risk (5).

Mannion et al. in Canada examined the growth parameters in newborn babies of mothers who consumed milk and vitamin D during pregnancy. Contrary to our study, it indicated that there was a significant correlation between the intake of vitamin D during pregnancy and birth weight. However, there was not a relationship between the intake of vitamin D during pregnancy and infant's head circumference and height. The study suggested that every 1-cup increase in daily milk consumption increased birth weight by 41 g; each 1-µg increase in daily vitamin D intake increased it by 11 g (21).

In their study, Karandish et al showed that calcium supplementation during pregnancy can increase birth weight independently of the duration of pregnancy (22).

In the present study, there was a direct and significant correlation between vitamin D, calcium, and phosphorus levels of mothers and those of the infants. A study by Maghbooli et al indicated that the serum level of vitamin D was strongly linked to the vitamin D level of umbilical cord blood. There was also a significant relationship between maternal and umbilical cord blood serum concentrations of calcium (14).

Conclusion

In the present study, weight and height of infants were affected by the maternal calcium level. More than two-thirds of mothers and more than half of the infants had vitamin D deficiency. Moreover, calcium deficiency was observed in one-third of mothers and 9.2% of infants, and phosphorus deficiency was observed in only 1% of mothers and 15.8% of infants. Due to the low intake of these substances through nutrition, it is necessary to pay special attention to adequate supply of these materials, especially vitamin D and calcium during pregnancy, and higher thresholds of these materials for pregnant women should be recommended.

Conflicts of Interest

There is no conflict of interest in this research.

Ethical considerations

The study was approved by the Ethics Committee of Shahrekord University of Medical Sciences (IR.SKUMS.REC.1394).

Acknowledgements

We gratefully acknowledge the financial support we received from Shahrekord University of Medical Sciences for this project.

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