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ORIGINAL ARTICLE

Association of antepartum vitamin D levels with postpartum pelvic floor muscle strength and symptoms

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Abstract
Introduction and hypothesis Vitamin D affects skeletal muscle strength and functions via various mechanisms. Strength and/or functional dysfunctions of the pelvic floor muscles may be associated with the distortion of pelvic floor functions. We hypothesized that vitamin D deficiency may contribute to pelvic floor dysfunction (PFD) by affecting pelvic floor muscle strength (PFMS). The aim of this study was to assess the effect of vitamin D deficiency during pregnancy on postpartum PFMS.
Methods This cross-sectional study was conducted in a university hospital. One hundred and eighty pregnant women were admitted to our hospital in their third trimester and compared with 156 healthy nulliparous women. Venous blood samples for examining vitamin D levels were taken from each participant and stored at −80 °C. At 8–10 weeks postpartum, patients were invited to the hospital, asked about their PFD symptoms, and PFMS was measured using a perineometer.
Results There was no statistical significance among groups regarding mean age, maternal age, and weight at delivery. Postpartum PFMS and duration in vitamin D-deficient women were significantly lower than those without the deficiency. Vitamin D-deficient vaginal delivery cases (group I) had a postpartum PFMS average of 21.96±7.91 cm-H_2O, nonvitamin D-deficient normal delivery cases (group III) had a PFMS of 29.66±10.3 cm-H_2O (p=0.001). In the cesarean delivery groups, vitamin D-deficient (group II) and nonvitamin D-deficient (group IV) cases had PFMS values of 32.23±9.66 and 35.53±15.58 cm-H_2O respectively (p=0.258).
Conclusions Lower vitamin D levels in the third trimester correlates with decreased PFMS.

Keywords Pelvic floor · Pregnancy · Vitamin D deficiency

Introduction

The effect of vitamin D on muscle strength and function has been shown in skeletal muscle cultures in animal and human studies [1]. The pelvic floor consists of mainly the levator ani and coccygeus muscles. Weakness of the pelvic floor muscles is manifested clinically by pelvic floor disorder (PFD) symptoms, which include urinary and fecal incontinence and pelvic organ prolapse. As in the skeletal muscles, the existence of vitamin D receptors in the detrusor has also been shown. Studies relating vitamin D deficiency to PFD are available in the literature [2]. The American National Health and Nutrition Examination Survey 2005–2006 reported a vitamin D deficiency in 69 % of the pregnant women evaluated [3]. We hypothesized that a woman who has a vitamin D deficiency during pregnancy may suffer from PFD after delivery. In various studies conducted in Turkey, the prevalence of vitamin D deficiency in pregnant women has been reported to be between 20 and 94.8 % [4, 5]. The aim of this study is to assess

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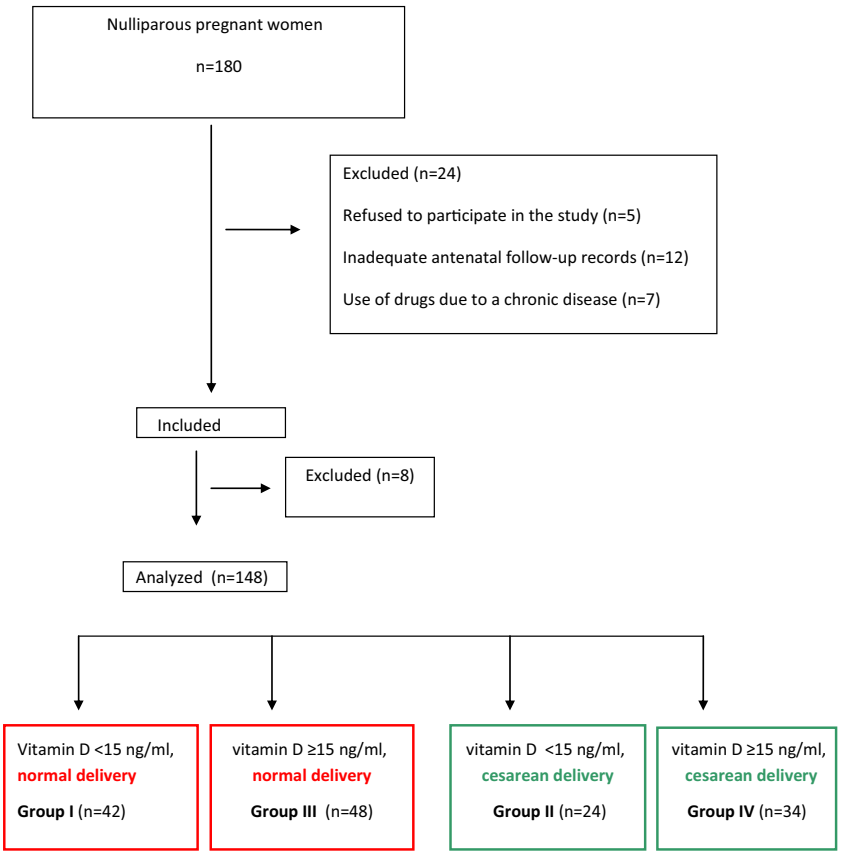

Fig. 1 Flowchart

the effect of vitamin D deficiency during pregnancy on postpartum pelvic floor muscle strength (PFMS).

Materials and methods

This cross-sectional study was conducted between April 2013 and January 2014 in Izmir Katip Celebi University Ataturk Research and Training Hospital in Izmir, Turkey. The study protocol was approved by the Izmir Katip Celebi University local ethics (committee IRB 2013-51). Informed consent was obtained from all participants and the study was in agreement with the Declaration of Helsinki for Medical Research Involving Human Subjects.

One hundred and eighty pregnant women admitted to our hospital in their third trimester, aged between 18 and 40 years, and 156 healthy, nulliparous women who met the criteria were included in our study. Multiparous women with diseases affecting vitamin D and calcium metabolism such as inflammatory bowel syndrome, gastric surgery, diabetes, thyroid and parathyroid diseases; multiple deliveries, history of vaginal surgery, previous application of epidural analgesia, use of medications during pregnancy because of a chronic disease, and women who refused postpartum hospital visits were also excluded from the study. Participants were asked to visit the hospital 8 weeks after delivery for measurements of PFMS. Venous blood samples for examining vitamin D levels were taken from each participant and stored at −80 °C. Five women

Table 1 Demographic features and postpartum pelvic floor muscle strength (PFMS) values of the cases

	Vaginal delivery groups		Cesarean delivery groups		*p*
	Group I (Vitamin D-deficient VD) *n*=42	Group III (Vitamin D-nondeficient VD) *n*=24	Group II (Vitamin D-deficient CD) *n*=48	Group IV (Vitamin D-nondeficient CD) *n*=34	
Maternal age	22.98±4.19	23.25±5.16	24.96±5.15	26.59±6.73	0.70
Gestational age (weeks)	38.8±1.73	38.9±2.65	39.2±1.33	38.7±2.22	0.702
Birth weight (g)	3,124.05±435.09	3,130.63±495.67	3,251.25±555.94	3,405.59±458.68	0.022
PFMS (cm H_2O)	21.96±7.91	29.66±10.3	32.23±9.66	35.53±15.58	0.001

Table 2 Postpartum pelvic floor muscle strength (PFMS) values of women who had normal and cesarean deliveries according to the vitamin D levels

	Normal delivery		*p*	Cesarean delivery		*p*
	Group I (Vitamin D deficient) *n*=42	Group III (Vitamin D nondeficient) *n*=24		Group II (Vitamin D deficient) *n*=48	Group IV (VD-non deficient) *n*=34	
PFMS (cm H_2O)	21.96±7.91	29.66±10.3	0.001	32.23±9.66	35.53±15.58	0.258
Time (s)	10.55±4.27	12.65±4.87		12.08±4.5	13.97±5.33	0.028

admitted during this period did not agree to participate, 19 women were excluded as they did not meet the inclusion criteria, and 8 women previously included in the study had to be excluded owing to loss of contact. Statistical analyses were performed on the remaining 148 cases (Fig. 1: flowchart).

After assessing the vital signs, general physical and obstetric status, and acquiring contact information, PFD symptoms during pregnancy were evaluated using the Urinary Distress Inventory short form (UDI-6) and the Incontinence Impact Questionnaire short form (IIQ-7) validated for Turkish-speaking populations [6].

After enrolling sufficient patients, serum 25(OH)D3 concentrations were measured using ELISA (Global Diagnostics & Medical Solutions KAP1971/GDMS, Belgium 13E27/2). Serum 25(OH)D concentrations <15 ng/mL were classified as a deficiency. Insufficient vitamin D status was defined as a serum 25[OH]D concentration between 15 and 29 ng/ml. Vitamin D levels >30 ng/ml were considered sufficient (intra-assay coefficient variability: 5.7 %, inter-assay coefficient variability: 4.7 %).

We recorded weeks' gestation at birth, type of delivery, and birth weight. Mediolateral episiotomy was performed in all vaginal deliveries. Patients were invited to the hospital 8–10 weeks postpartum and subjects were questioned about PFD symptoms. PFMS was measured in the lithotomy position using a digital perineometer (Extt-101; Apimeds, Gyeonggi-do, South Korea). The probe, which was automatically insufflated by the device with 40 ml of air, was placed at the level of the hymenal ring in the vagina. At the initiation of the process the patient was asked to "squeeze" the probe using her pelvic floor muscles. The moment the patient relaxed her muscles, the duration and the pressure applied appeared on the screen of the perineometer and the measurement was terminated. After ensuring patient co-operation, the highest of three measurements obtained was recorded. PFMS measured by perineometer correlated with PFMS measured by clinical perineometry. Pressure values, obtained in mm Hg, were multiplied by 1.359 for conversion into cmH_2O and recorded as such.

Patients were defined as follows: vitamin D level <15 ng/ml and normal delivery as group I (*n*=42); vitamin D <15 ng/mL and cesarean delivery as group II (*n*=24); vitamin D≥15 ng/ml and normal delivery as group III (*n*=48), and vitamin D≥15 ng/mL and cesarean delivery as group IV (*n*=34; Fig. 1).

Statistical analysis was performed using SPSS for Windows (version 16.0 2006). Categorical variables were assessed using the Chi-squared test. The numerical variables were analyzed using Student's *t* test and one-way

Table 3 Linear regression analysis for variables thought to affect PFMS among the groups

Mode of delivery	95 % confidence interval			*p*
Vaginal birth	Constant	−5.115	62.571	0.095
	Maternal age (years)	−0.125	0.659	0.180
	Birth weight (g)	−0.011	−0.001	0.017
	Vitamin D level (mg/dl)	0.173	0.432	0.000
	UDI-6	−0.247	0.026	0.112
	Gestational age (weeks)	−0.121	0.166	0.758
Cesarean section	Constant	−56.662	84.659	0.693
	Maternal age (years)	−0.429	0.719	0.615
	Birth weight (g)	−0.013	0.002	0.148
	Vitamin D level (mg/dl)	0.029	0.895	0.037
	UDI-6	−0.648	−0.231	0.000
	Gestational age (weeks)	−0.166	0.424	0.385

Table 4 Correlation analysis of the factors thought to affect PFMS

	PFMS		Vitamin D	
	r	*P*	r	*p*
Vaginal delivery				
Maternal age	0.144	0.177	−0.009	0.932
Birth weight	−0.209	0.048	0.073	0.495
Vitamin D	0.426	0.000	1.000	
UDI-6	−0.151	0.156	−0.085	0.428
Gestational age	−0.084	0.434	0.051	0.634
Cesarean section				
Maternal age	−0.008	0.954	0.350	0.007
Birth weight	−0.036	0.787	0.149	0.266
Vitamin D	0.335	0.010	1.000	
UDI-6	−0.521	0.000	−0.158	0.236
Gestational age	−0.128	0.340	−0.043	0.748

Table 5 Multivariate linear regression analysis of the factors thought to affect PFMS

	B	Standard Error	Beta	t	Significance	95 % CI		R2	F	*p*
Cesarean delivery										
(Constant)	33.017	4.432		7.450	0.000	24.135	41.898	0.312	13.950	0.001
UDI-6	−0.386	0.089	−0.480	−4.313	0.000	−0.565	−0.207			
Vitamin D	0.456	0.196	0.259	2.329	0.024	0.064	0.848			
Vaginal delivery										
(Constant)	36.709	6.379		5.755	0.000	24.031	49.388	0.222	13.687	0.001
Vitamin D	0.310	0.066	0.443	4.728	0.000	0.180	0.441			
Birth weight	−0.005	0.002	−0.242	−2.578	0.012	−0.009	−0.001			

ANOVA. Correlation analysis was performed to investigate the relationship between maternal serum 25(OH)D concentrations and PFMS. Pearson′s correlation test was used to evaluate the factors related to maternal serum 25 (OH) vitamin D concentrations. Stepwise test was used for multivariate linear regression analysis. *P* values <0.05 were considered statistically significant.

Results

Demographic data of the four groups were summarized in Table 1. In the vaginal delivery group 63.6 % and in the cesarean delivery group 58.5 % had vitamin D deficiency. Postpartum PFMS values were highest in nonvitamin D-deficient women who had a cesarean delivery (group IV), and lowest in vitamin D-deficient women who had a normal delivery (group I; Table 2). Postpartum PFMS in vitamin D-deficient women who delivered normally were significantly lower than those without the deficiency. The difference was not significant for women who had cesarean deliveries (Table 2).

Linear regression analysis of vitamin D levels with muscle strength and endurance among groups showed a positive correlation between vitamin D levels and PFMS, both in normal and cesarean deliveries (Table 3). While birth weight in normal deliveries was included in the parameters affecting PFMS, it had no effect on cesarean deliveries. Moreover, the rate of fetal macrosomia was reported to be 4.5 % in normal deliveries and 7.3 % in cesarean deliveries; the difference was not statistically significant (p=0.509). Correlation analysis of vitamin D levels with muscle strength and endurance among groups showed a moderately positive correlation between vitamin D level and PFMS, and a mildly negative correlation between birth weight and PFMS in the vaginal delivery group. In the caesarean delivery group the correlation between vitamin D level and PFMS was found to be mildly positive, whereas a moderately negative correlation was detected between the UDI score and PFMS (Table 4). In the multivariate linear regression analysis examining the factors affecting PFMS confirmed these results (Table 5). The second phase of the delivery was not permitted to last more than 2 h.

The UDI-6 and IIQ-7 were conducted to assess the impact of concomitant lower urinary symptoms on life quality during pregnancy and yielded scores of 29.52±17.39 and 5.98±10.32 (p=0.20) respectively, in vitamin D-deficient women, and 21.09±13.1 and 5.86±11.19 (p=0.80) in nonvitamin D-deficient women. Although life quality scores were worse in vitamin D-deficient patients compared with nonvitamin D-deficient patients, the difference was not significant (Table 6). UDI-6 and IIQ-7 scores in both groups declined in the postpartum period. UDI-6 scores in vitamin D-deficient and nondeficient patients were 8.34±2.08 and 4.26±1.14 (p=0.431) respectively, and IIQ-7 scores were 2.21±1.72 and 1.18±0.87 (p=0.04) respectively.

Regarding the seasonal distribution of vitamin D levels, although the average of levels measured in July, August, and September (19.13±13.4 ng/dl; n=102) were higher than the average of other months (15.97±8.11 ng/dl; n=46) the difference was not statistically significant (p=0.064).

Table 6 Antepartum and postpartum UDI-6 and IIQ-7 values of the groups

	Antepartum		*p*	Postpartum		*p*
	Vitamin D-deficient	Vitamin D-nondeficient		Vitamin D-deficient	Vitamin D-nondeficient	
UDI-6	29.52±17.39	21.09±13.1	0.20	8.34±2.08	4.26±1.14	0.43
IIQ-7	5.98±10.32	5.86±11.19	0.80	2.21±1.72	1.18±0.87	0.04

Discussion

In this cross-sectional study, the mean PFMS of vitamin D-deficient primigravid women was significantly lower than the mean PFMS of nonvitamin-deficient women 8 weeks after delivery.

In recent years, studies investigating the association between pelvic floor dysfunction and vitamin D have been published. In the first study showing the relationship of PFD to vitamin D deficiency, Dallosso et al. showed that overactive bladder symptoms decreased with high vitamin D intake [7]. Several studies suggest that vitamin D deficiency might contribute to the development of pelvic floor disorders, such as urinary/fecal incontinence and pelvic organ prolapse, by reducing PFMS [2, 7, 8]. More recently, the PFD risk in women older than 20 with high vitamin D levels has been reported to decrease and this association becomes stronger with increasing age [2]. Parker-Autry et al. reported that among woman with a PFD, 51 % had a vitamin D insufficiency/deficiency as defined by a vitamin D level <30 ng/ml. [9].

Vitamin D deficiency is between 36 and 100 % in various populations [10–14]. A high prevalence of vitamin D deficiency in pregnant women has been shown in numerous studies [3–5, 15, 16]. In this study, we investigated the impact of vitamin D deficiency on PFMS in pregnant women and its relationship with the PFD symptoms.

Vitamin D deficiency is known to cause skeletal muscle weakness. Weakness of the levator muscle group, which provides essential support to the pelvic floor, is the main factor in PFD. Low postpartum PFMS in vitamin D-deficient women may be an indication that vitamin D deficiency is one of the factors contributing to PFD.

In vivo studies have shown that vitamin D receptors are found in the bladder neck, urothelium, and muscular layers of the bladder wall [17]. Vitamin D deficiency is likely to deteriorate calcium homeostasis, resulting in abnormal detrusor contractility. Attenuated detrusor muscles may proceed to a hypercontractile or irritable state. In addition, vitamin D deficiency may stimulate an increase in inflammatory cytokine production from the urothelium, leading to inflammation of the bladder wall. In order to assess the relationship between vitamin D deficiency and urinary symptoms, we used the UDI-6 and IIQ-7 questionnaires; both the presence and the impact of these symptoms on the daily activities of women were evaluated. UDI-6 and IIQ-7 scores were slightly higher for women with a vitamin D deficiency than for women without a vitamin D deficiency, but the difference was not significant during the postpartum period. In the postpartum evaluation, the UDI-6 and IIQ-7 scores of both groups were significantly reduced (p=0.04; Table 5). While the prevalence of urinary incontinence in the postpartum period was reported to be 6–29 %, during pregnancy the rate was as high as 23–67 %; our findings are consistent with those in the literature [18, 19]. The decrease in the scores of UDI-6 and IIQ-7 in the postpartum period may be related to a reduced frequency of urination owing to the fading mass effect of the uterus on the bladder, reduction of the intra-abdominal pressure, and reversal of the glomerular filtration rate back to the pre-pregnancy values.

The strengths of our study are that, it is to our knowledge the first cross-sectional study investigating the relationship between pelvic floor functions and vitamin D status in pregnancy and during the postpartum period. Furthermore, our use of a digital perineometer to evaluate the muscle strength of the pelvic floor ensured a relatively objective measurement. Finally, sufficient participants was obtained. Limitations include the absence of PFMS measurements during pregnancy, thus hindering the determination of a prepartum vitamin D and PFMS association, which in turn makes it impossible to compare prepartum and postpartum muscle strength. The reason for a lack of PFMS measurement during pregnancy was that no vaginal examinations were made in the prepartum period unless required, because of women's negative attitudes towards vaginal examinations during pregnancy in our country.

Conclusions

Aside from the mechanical and neurological trauma generated by the process of pregnancy and delivery, other factors that affect the strength of the pelvic floor muscles also contribute to the development of PFD. Vitamin D deficiency in pregnant women may be effective in postpartum PFD development by reducing PFMS. In addition to the positive effects of vitamin D supplementation during the course of pregnancy, randomized control trials are necessary to support the suggestion that vitamin D supplements might also contribute to the prevention of PFD.

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Authors' contributions S. Aydogmus: protocol/project development, manuscript writing; S. Kelekcı: manuscript editing, scientific supervision; H. Aydogmus: data collection and management; M. Demir: data collection; B. Yilmaz: data collection; R. Sutcu: data analysis.

Conflicts of interest None.

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