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An Exploratory Study of Postpartum Depression and Vitamin D

Pamela K. Murphy[1], Martina Mueller[2], Thomas C. Hulsey[3], Myla D. Ebeling[4], and Carol L. Wagner[5]

Abstract

BACKGROUND: Low levels of serum 25-hydroxyvitamin D (25[OH]D), a reliable measurement of vitamin D, have been implicated in several mood disorders. To date, studies exploring the relationship between vitamin D and postpartum depression are absent from the literature. **OBJECTIVES:** To determine whether a relationship exists between symptoms associated with postpartum depression and vitamin D levels and to determine if serum 25(OH)D levels can predict the incidence of symptoms associated with postpartum depression. **STUDY DESIGN:** An exploratory, descriptive study using a convenience sample of 97 postpartum women attending seven monthly visits. Women provided serum 25(OH)D samples and completed the Edinburgh Postpartum Depression Scale (EPDS) at each visit. **RESULTS:** A significant relationship over time was found between low 25(OH)D levels and high EPDS scores, indicative of postpartum depression. **CONCLUSIONS:** Future rigorous studies investigating vitamin D and postpartum depression are warranted with larger sample sizes using confirmatory methods to diagnose postpartum depression.

Keywords

postpartum depression, vitamin D, 25(OH)D, EPDS, 25-hydroxyvitamin D

Several studies have found mood disorders (premenstrual syndrome, seasonal affective disorder, nonspecified mood disorder, and major depressive disorder) to be significantly associated with low levels of serum 25-hydroxyvitamin D (25[OH]D), a reliable measurement of vitamin D (Murphy & Wagner, 2008). Research exploring the implications of decreased levels of vitamin D on the incidence of postpartum depression is absent from the literature. Postpartum depression is a devastating mood disorder that afflicts 13% of postpartum women in the months following delivery (O'Hara & Swain, 1996).

Postpartum depression not only affects the woman herself but her children and significant others as well (Centers for Disease Control and Prevention [CDC], 2004). Identified risk factors predisposing a woman to postpartum depression include the following: single marital status, poor marital relationship, poor social support, poor socioeconomic status, less than 12 years of education, low self-esteem, life stress, child care stress, prenatal depression, history of depression, prenatal anxiety, fatigue, difficult infant temperament, multiparity, and unplanned or unwanted pregnancy (Beck, 2008; Beck & Gable, 2001; CDC, 2004; Dennis, Janssen, & Singer, 2004; Nielsen, Videbach, Hedegaard, Dalby, & Secher, 2000; Righetti-Veltema, Conne-Perreard, Bousquet, & Manzano, 1998).

Vitamin D is manufactured by the epidermis when exposed to UVB rays or absorbed through the gastrointestinal system through dietary means. Vitamin D is not biologically active until it is metabolized in the liver into 25(OH)D and subsequently converted to 1,25-dihydroxyvitamin D (1,25$[OH]_2$D) in the kidneys and other extrarenal tissues. This active form of vitamin D then binds to vitamin D receptors (VDRs) to regulate cellular function in

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several tissues located in the body, including brain neurons (Zittermann, 2003). It take 3 months of a consistent vitamin D regimen for 25(OH)D levels to stabilize (Heaney, Davies, Chen, Holick, & Barger-Lux, 2003; Vieth, 1999; Vieth, Chan, & MacFarlane, 2001).

Vitamin D insufficiency (25[OH]D < 32 ng/mL) is epidemic and affects up to 75% of women in their childbearing years (Wagner, Johnson, et al., 2008). This high incidence of vitamin D insufficiency is because of the decreased UVB sunlight exposure due to seasonality (fall and winter months have shorter daylight hours and less intense UVB rays), latitude of residence (farther distances from the equator have less intense rays as well), greater body mass, darker skin pigmentation, and use of sunscreen and protective clothing (Nesby-O'Dell et al., 2002; Wagner, Johnson, et al., 2008; Wagner, Taylor, & Hollis, 2008).

Theoretical Link Between Postpartum Depression and Vitamin D

The biological mechanism linking vitamin D with mood disorders is still unclear. This mechanism could be related to the location of VDRs within the brain. VDRs are inadequately filled in the presence of vitamin D deficiency (25[OH]D < 20 ng/mL), which may interfere with proper functioning of hormonal processes that prevent disease within the brain, such as mood disorders (Garland et al., 2006).

A recent clinical study found a relationship between VDRs and glucocorticoid signaling regulation in rat models (Obradovic, Gronemeyer, Lutz, & Rein, 2006), an important finding as dysfunctional glucocorticoid signaling has been implicated in major depressive disorder. Decreased bone mineral density (Altindag et al., 2007), resulting from vitamin D deficiency (Holick, 2007), has also been implicated in major depressive disorders, and it is possible that inadequately saturated VDRs are also the culprit in this recent finding. Although exact mechanisms for the link between vitamin D, VDRs, and mood disorders such as postpartum depression have yet to be determined, evidence exists to support research exploring these associations.

If vitamin D can be identified as a risk factor for postpartum depression, vitamin D supplementation may reduce the incidence of postpartum depression for those women who are at risk of developing postpartum depression because of their low vitamin D status. Therefore, this exploratory study was conducted to determine (a) whether a longitudinal relationship exists between symptoms associated with postpartum depression and vitamin D and (b) whether vitamin D levels, specifically serum 25(OH)D, can predict the incidence of symptoms associated with postpartum depression.

Method

Participants

A convenience sample of women who were participating in an ongoing institutional review board (IRB)–approved National Institute of Health (NIH) funded, R01 study between January and December 2008 at the Medical University of South Carolina in Charleston, were included in this IRB-approved, quantitative, descriptive, exploratory study (HR#10727). These women received compensation for their participation in the study. Participants gave informed consent and met all of the following inclusion criteria: aged 18 to 45 years, delivered an infant who was at least 35 weeks gestation and were 4 to 6 weeks postpartum at the initial study visit, spoke English or Spanish as their primary language, and exclusively breast-fed or formula-fed their infant for the entire study period. Because this cohort was part of a larger study, the 97 participants were also taking one of three vitamin D_3 supplementation doses daily—400, 2,000, or 6,000 IU—in addition to a prenatal vitamin containing 400 IU vitamin D_3 per day. Potential participants were excluded from this cohort if they had given birth to multiples or had preexisting type 1 or type 2 diabetes, hypertension, parathyroid disease, or uncontrolled thyroid disease.

Procedures

Women were invited to attend seven monthly visits during the first 7 months postpartum. At each monthly visit, women complete demographical questionnaires (administered as part of the parent R01) and the Edinburgh Postnatal Depression Scale (EPDS). In addition, maternal circulating 25(OH)D levels were measured monthly. Participants were included in this study if they completed at least the first of the seven visits during the stated time frame.

Instruments

Demographic questionnaires. Demographical questionnaires were administered to determine each participant's age, race, marital status, insurance type, educational level, whether the pregnancy was planned, and method of infant feeding (breast milk or formula). Season in which the visit was attended was also recorded.

Edinburgh Postnatal Depression Scale. The EPDS (Cox, Holden, & Sagovsky, 1987) is a screening instrument that identifies postpartum women suffering from depressive symptoms. The scale consists of 10 short statements with responses scored as 0, 1, 2, or 3 and takes approximately 5 minutes to complete. Participants are asked to respond to statements that come closest to how she has felt in the past 7 days, for example, whether she is able to laugh or see

the funny side of things. The mother completes the scale herself, unless she has difficulty reading. Cutoff scores to identify women who exhibit high levels of postpartum depressive symptoms vary from 9 to 14. For this study, a cutoff score of 9 was chosen to identify women at risk for both minor (subclinical) and major postpartum depression to identify the maximum number of women exhibiting symptoms warranting follow-up. If a woman scored 9 or greater, she was referred to her health care provider for further evaluation and treatment. If a woman responded positively to question 10 (suicidal ideation), she was referred to the ER for further mental health evaluation.

A cutoff score of 9 yields a sensitivity of 68% to 80% (Murray & Carothers, 1990; Lawrie, Hofmeyr, de Jager, & Berk, 1998) and a specificity of 77% (Lawrie et al., 1998). The use of this scale in a Spanish-speaking population has been tested and results vary according to the woman's country of origin. For example, in a sample of Mexican women, a cutoff score of 7 to 8 yields a sensitivity of 75% and a specificity of 84% (Alvarado-Esquivel, Sifuentes-Alvarez, Salas-Martinez, & Martinez-Garcia, 2006), whereas in a sample of Peruvian women, a cutoff score of 13 to 14 yields a sensitivity of 84% and a specificity of 79% (Vega-Dienstmaier, Mazzotti Suarez, & Campos Sanchez, 2002). For consistency, a cutoff score of 9 was used for women whose primary language was Spanish and completed the Spanish-language version of the EPDS.

Serum 25(OH)D. Serum 25(OH)D is used to measure vitamin D status because it is the major circulating and most stable form of vitamin D (Armas, Hollis, & Heaney, 2004). To determine serum 25(OH)D values, a rapid direct radioimmunoassay (RIA) for 25(OH)D was used. The reagents for the ^{125}I-labeled RIA for 25(OH)D were purchased from Diasorin Corporation (Stillwater, MN).

Once serum 25(OH)D is determined, levels are classified into three categories: vitamin D deficiency, insufficiency, and sufficiency. Current guidelines define vitamin D deficiency as serum levels of 25(OH)D below 20 ng/mL, insufficiency as serum levels between 20 and 32 ng/mL, and sufficiency as serum levels greater than 32 ng/mL, although there is debate this level may need to be increased to 40 ng/mL (Cannell & Hollis, 2008; Hollis, 2005a, 2005b; Vieth et al., 2007).

Statistical Analysis

Demographic and clinical characteristics among postpartum women were compared across two vitamin D categories (defined in this study as follows: insufficiency, 25(OH)D ≤ 32 ng/mL; sufficiency, 25(OH)D > 32 ng/mL) using pooled *t* tests for continuous variables and chi-square tests for categorical variables. Unadjusted mean EPDS sum scores were compared at each time point for the insufficient (≤32) versus sufficient (>32) vitamin D level groups using pooled *t* tests. A linear mixed models (LMM) approach was used to assess the longitudinal relationship of depression as measured by EPDS sum score and vitamin D level. The LMM approach can accommodate multilevel data from longitudinal, repeated measurements on subjects, measurements taken at different time points, missing data, and time-varying covariates.

All models contained the EPDS sum score as the response variable, visit and vitamin D level as primary variables of interest, and a person-level random effect to account for correlation of measurements within individuals and adjustment for the EPDS sum score at baseline. Models were further adjusted for demographic (age, race/ethnicity, gender, marital status, insurance status) and clinical covariables (season, feeding method, vitamin D dose, planned pregnancy) to account for baseline differences. Model building was carried out in a sequential fashion. The first model included vitamin D level dichotomized into ≤32 ng/mL and >32 ng/mL as the primary independent variable of interest, visit, a visit-by-vitamin D level interaction term, and EPDS sum score at baseline. Next, all demographic and all clinical variables were added to the model. The final adjusted model (full model) included the primary independent variable (vitamin D level), visit, visit-by-vitamin D level interaction, and the adjustment covariables age, gender, educational level, marital status, insurance level, season, breast-feeding or bottle feeding, vitamin D dosage, and whether or not the pregnancy was planned. Adjusted mean EPDS sum scores were compared for the insufficient versus sufficient vitamin D level groups for each of the sequentially built models.

In additional analysis, sensitivity of the findings was assessed using a series of cut-points for dichotomizing vitamin D level. The final LMM was used to determine adjusted mean EPDS sum scores for each of the cut-points.

A two-tailed $\alpha = .05$ level of significance was used for all statistical tests. Analyses were performed using SAS statistical software, Version 9.1.3 (SAS Institute Inc., Cary, NC).

Results

In Table 1 demographic and clinical characteristics of the study participants are compared by vitamin D level (≤32 vs. >32 ng/mL) group. Women with insufficient baseline vitamin D levels (25[OH]D ≤ 32) were on average approximately 2 years younger than women with sufficient baseline levels (25[OH]D > 32; $t(94) = 1.8$, $p = .07$). More White women had sufficient baseline vitamin D levels compared with Black/African American women or women who self-identified as Asian or Hispanic ($\chi^2(2, N = 97) = 25.3$, $p < .0001$). In the group having sufficient baseline vitamin D levels more women were married, had private insurance, had a higher educational level, and

Table 1. Baseline Demographic and Clinical Characteristics of the Study Sample

	Total ($N = 97$)	Vitamin D Insufficiency, 25(OH)D ≤ 32 ng/mL ($n = 56$)	Vitamin D Sufficiency, 25(OH)D > 32 ng/mL ($n = 41$)	χ^2 Value (t for Age)	p Value
Age	28.9 ± 5.5	28.1 ± 5.9	30.1 ± 4.8	−1.8[a]	.07
Race/ethnicity				25.3[b]	<.0001
White	44.3% (43/97)	23.2% (13/56)	73.2% (30/41)		
Black/African American	30.9% (30/97)	46.4% (26/56)	9.8% (4/41)		
Hispanic	23.7% (23/97)	30.4% (17/56)	14.6% (6/41)		
Asian	1.0% (1/97)	0	2.4% (1/41)		
Marital status				12.8[c]	.0003
Single	37.1% (36/97)	46.4% (26/56)	24.4% (10/41)		
Married	49.5% (48/97)	33.9% (19/56)	70.7% (29/41)		
Separated/divorced	1.0% (1/97)	1.8% (1/56)	0		
Partnered	13.4% (12/97)	17.9% (10/56)	4.9% (2/41)		
Type of insurance				8.5[d]	.004
None	20.6% (20/97)	26.8% (15/56)	12.2% (5/41)		
Private	39.2% (38/97)	26.8% (15/56)	56.1% (23/41)		
Medicaid	38.1% (37/97)	46.4% (26/56)	26.8% (11/41)		
Unknown	2.1% (2/97)	0	4.9% (2/41)		
Educational level				8.5[e]	.004
Less than high school	10.3% (10/97)	12.5% (7/56)	7.3% (3/41)		
High school	25.8% (25/97)	35.7% (20/56)	12.2% (5/41)		
Undergraduate degree	43.3% (42/97)	42.9 (18/56)	43.9% (18/41)		
Graduate degree	20.6% (20/97)	8.9% (5/56)	36.6% (15/41)		
Feeding type				3.2	.072
Breastfeeding	76.3% (74/97)	69.6% (39/56)	85.4% (35/41)		
Formula feeding	23.7% (23/97)	30.4% (17/56)	14.6% (6/41)		
Season visit occurred				3.5	.061
Spring/summer (April-September)	47.4% (46/97)	39.3% (22/56)	58.5% (24/41)		
Fall/winter (October-March)	52.6% (51/97)	60.7% (34/56)	41.5% (17/41)		
Dose taken				1.1	.587
2,000 IU	32.0 %(31/97)	35.7% (20/56)	26.8% (11/41)		
6,000 IU	32.0% (31/97)	28.6% (16/56)	36.6% (15/41)		
Control	36.1% (35/97)	35.7% (20/56)	36.6% (15/41)		
Planned pregnancy	50.0% (45/90)	39.6% (21/53)	64.9% (24/37)	5.6	.018

Note. 25(OH)D = 25-hydroxyvitamin D.
a. p Value from pooled t test.
b. p Value for White versus Black/African American versus Asian or Hispanic.
c. p Value for married versus not married.
d. p Value for private versus not private.
e. p Value for high School or less versus some higher education.

reported to have planned the pregnancy than women with insufficient baseline vitamin D levels.

Twelve percent of the participants scored >9 at visit 1, indicating greater symptoms associated with postpartum depression. Women with scores >9 tended to be Hispanic, be separated or divorced, be uninsured, have not attained a high school degree, have chosen to formula feed their infants, or have had their visits during the fall and winter months (significant result, $p < .05$).

Unadjusted mean EPDS sum scores are presented for the two groups in Figure 1. At all seven time points (monthly visits) unadjusted mean EPDS sum scores were consistently higher in the group with lower vitamin D levels (25[OH]D ≤ 32 ng/mL) than in the higher vitamin D level (25[OH]D > 32 ng/mL) groups, indicating a negative relationship of EPDS scores with vitamin D level, though no differences showed statistical significance (Table 2).

Adjusted mean EPDS sum scores over seven visits are presented in Table 3 for all sequentially built models. Over all models adjusted mean EPDS sum scores were lower for the group having higher vitamin D levels. For the base model containing only EPDS score as dependent variable,

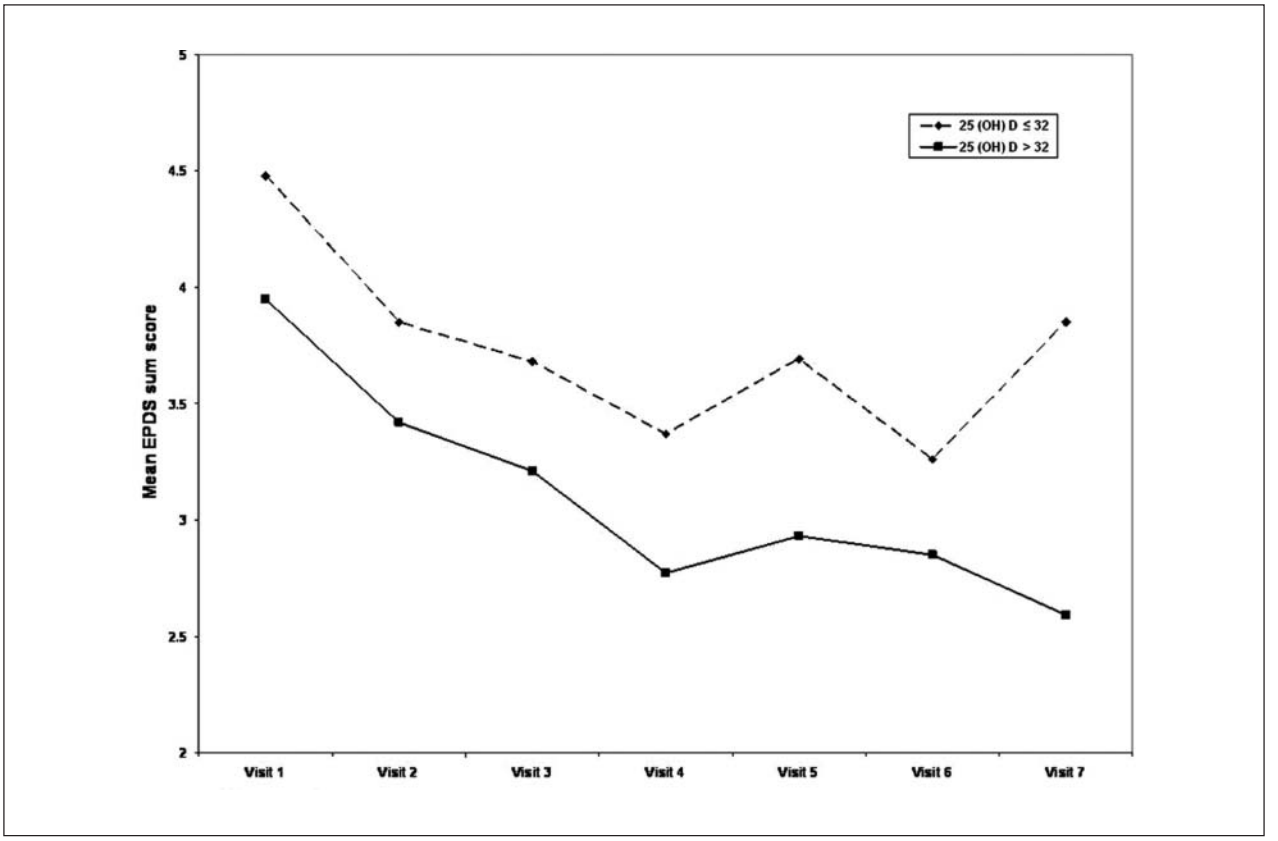

Figure 1. Unadjusted mean EPDS sum scores by 25(OH)D level category by time points.

vitamin D category as primary independent variable, and visit and baseline EPDS score as adjustment variables, the difference in EPDS score between the two vitamin D groups was not statistically significant, whereas the models adjusted for demographics and clinical variables showed marginally significant differences in EPDS sum scores between the groups. Adjusted mean EPDS sum scores over time in the final model containing all demographic and clinical covariables were statistically significantly lower for the group with vitamin D levels above 32 ng/mL compared with the group at or below 32 ng/mL ($\Delta = 0.8 \pm 0.3$, $t(388) = 2.3$, $p = .02$).

In Table 4, estimates for all fixed effects included in the final LMM are provided. Mothers with lower levels of vitamin D had higher EPDS sum scores over time than mothers with higher vitamin D levels ($p = .02$). Controlling for all other variables in the model baseline EPDS sum score and marital status were associated with EPDS sum score. Specifically, EPDS sum scores were negatively associated with not being married ($p = .02$). A one-unit increase in baseline EPDS sum score was expected to increase the mean EPDS sum score by 0.66 ($p < .0001$). Controlling for all other variables, EPDS sum score was positively associated with participation in the study during spring or summer and breast-feeding. Specifically, expected mean EPDS sum scores over time were 0.85 units higher for women participating during fall or winter compared with women enrolling in spring or summer ($p = .06$) and 0.94 units higher for women who bottle-fed their infant compared with women who breast-fed ($p = .07$).

Table 5 presents mean EPDS sum scores over seven visits for different cut-points used to dichotomize vitamin D level. Scores were consistently higher for the group having lower vitamin D levels regardless of the cut-point. Differences in EPDS sum scores over time were not statistically significant using 20, 50, or 60 ng/mL as the cut-point, whereas mean EPDS sum scores over time between the groups for cut-points of 30, 32, or 40 ng/mL were statistically significantly different ($p = .02$, $p = .02$, and $p = .05$, respectively).

Discussion

This exploratory study represents a first attempt to identify whether a relationship exists between vitamin D and postpartum depression. Vitamin D insufficiency may not be the only variable contributing to the incidence of postpartum depression; however, it is one that can be easily identified and corrected under the supervision of a health care provider.

Table 2. Unadjusted Mean EPDS Sum Scores (± Standard Deviation) by Vitamin D Level Category by Time Points (Monthly Visits)

EPDS Mean Score	*N*[a]	Vitamin D ≤ 32 ng/mL	Vitamin D > 32 ng/mL	Difference	*t* Value	*p* Value
Visit 1	86	4.48 ± 4.41	3.95 ± 3.39	0.53 ± 4.00	0.63	.529[b]
Visit 2	77	3.85 ± 3.61	3.42 ± 3.59	0.43 ± 3.60	–0.52	.606
Visit 3	74	3.68 ± 4.42	3.21 ± 3.72	0.47 ± 4.03	0.49	.623
Visit 4	70	3.37 ± 4.04	2.77 ± 3.30	0.60 ± 3.69	0.50	.498
Visit 5	59	3.69 ± 4.28	2.93 ± 3.65	0.76 ± 3.97	0.73	.467
Visit 6	57	3.26 ± 3.90	2.85 ± 3.65	0.41 ± 3.75	0.40	.689
Visit 7	55	3.85 ± 4.39	2.59 ± 2.96	1.26 ± 3.70	1.23	.223[b]

Note. EPDS = Edinburgh Postpartum Depression Scale.
a. Total *N* at each time point.
b. *p* Value for unequal variances.

Table 3. Comparison of Adjusted Mean EPDS Sum Scores (± Standard Error) by Vitamin D Category From Sequentially Built Models

	Vitamin D ≤ 32 ng/mL	Vitamin D > 32 ng/mL	Difference	*t* Value	*p* Value
Base model (BM)[a]	3.71 ± 0.24	3.38 ± 0.24	0.32 ± 0.29	1.11	.267
BM + demographic cov.[b]	3.77 ± 0.27	3.18 ± 0.29	0.59 ± 0.31	1.90	.058
BM + clinical cov.[c]	3.58 ± 0.27	3.03 ± 0.28	0.55 ± 0.31	1.80	.073
BM + all covariables (final)	3.68 ± 0.30	2.92 ± 0.32	0.76 ± 0.33	2.32	.021

Note. EPDS = Edinburgh Postpartum Depression Scale.
a. Base model contains EPDS sum score as dependent variable, vitamin D category (≤32 vs. >32 ng/mL) as primary independent variable of interest, and the adjustment variables visit (to represent time) and EPDS sum score at baseline. Vitamin D level category-by-visit interaction: $p = .694$.
b. Demographic covariables: age, race/ethnicity, gender, marital status, insurance status.
c. Clinical covariables: season, feeding method, vitamin D dose, planned pregnancy.

Incidence of Postpartum Depression and Vitamin D Deficiency

Postpartum depression. In our sample, the number of women who screened higher for postpartum depressive symptoms using the EPDS (12% of the participants with a sum score >9) in the first 4 to 6 weeks postpartum is consistent with a meta-analysis reporting 13% of postpartum women diagnosed with postpartum depression (O'Hara & Swain, 1996).

Vitamin D. The incidence of vitamin D insufficiency and/or deficiency (75%) was slightly less in our sample than a recent study done in a sample of pregnant women at our own center, the Medical University of South Carolina in Charleston, which that reported 82% of women had insufficiency and/or deficiency (Wagner, Johnson, Hulsey, Hamilton, McNeil, Dais, Pridgen, & Hollis, 2008). There is a disparity in vitamin D insufficiency between darker pigmented participants (77%) and lighter pigmented participants (23%). Out of all the participants, 10 African American women had taken vitamin D supplementation during pregnancy as part of another study, and therefore, their baseline vitamin D status reflects their having taken a vitamin D supplement during pregnancy; however, only 9.8% of African American participants ($n = 30$) had a sufficient level (25[OH]D > 32 ng/mL) of vitamin D.

Relationship Between Postpartum Depression and Vitamin D

There are a multitude of factors that place a woman at risk for developing postpartum depression, such as age, race/ethnicity, marital status, type of insurance, educational level, feeding type, and whether or not the pregnancy was planned (Beck, 2008; Beck & Gable, 2001; CDC, 2004; Dennis et al., 2004; Nielsen et al., 2000; Righetti-Veltema et al., 1998). In addition, serum 25(OH)D levels can be influenced by the season (accounting for the amount and strength of UVB exposure) and vitamin D supplementation. In this study, when controlling for the above-mentioned variables, a significant relationship over time was found between high EPDS scores and low vitamin D levels during the first 7 months postpartum ($p = .02$). The same relationship was consistently found for unadjusted means across all visits, though not statistically significant, and for adjusted means using different cut-points for determination of sufficient versus insufficient vitamin D categories. Therefore, if a pregnant or postpartum woman is identified with insufficient

Table 4. Estimates for Linear Mixed Model of Vitamin D Level and EPDS Sum Score Adjusting for Demographic and Clinical and Characteristics

Variable	Estimate	Standard Error	*F* Value	*p* Value
Vitamin D level (≤32 ng/mL)	0.761	0.328	5.38	.021
Visit	–0.207	0.063	10.7	.002
Baseline EPDS sum score	0.659	0.051	168.6	<.0001
Age	0.047	0.048	0.95	.333
Race/ethnicity			0.37	.690
Black, African-American	–0.016	0.737		.983
Asian or Hispanic	–0.568	0.806		.484
Marital status (not married)	–1.558	0.624	6.24	.015
Educational level (less than or equal to high school)	0.725	0.627	1.34	.251
Insurance level (private)	–0.958	0.642	2.22	.141
Dose			0.49	.616
2,000 IU	0.268	0.499		.594
6,000 IU	0.509	0.516		.328
Season (April-September)	0.852	0.446	3.64	.060
Feeding (breast)	0.936	0.516	3.29	.074
Planned pregnancy (no)	0.458	0.528	0.75	.389

Note. EPDS = Edinburgh Postpartum Depression Scale.

vitamin D levels, she may be more at risk for developing symptoms associated with postpartum depression.

Implications for Clinical Practice

Although the findings of this exploratory study implicate an association between vitamin D insufficiency and greater symptoms of postpartum depression, routine testing of serum 25(OH)D cannot be recommended to screen for postpartum depression risk until a larger study using methods to diagnose postpartum depression is conducted. However, nurse-practitioners are in an ideal situation to educate women about the benefits of adequate levels of vitamin D for their overall health and recommend routine screening of serum 25(OH)D to ensure they remain vitamin D sufficient throughout their lifespan.

Table 5. Sensitivity Analysis of Adjusted Mean EPDS Sum Scores (± Standard Error) Using Final Model With Varying Vitamin D Level Cut-Points

Cut-Point	Vitamin D ≤ Cut-Point	Vitamin D > Cut-Point	Difference	*p* Value
20	3.79 ± 0.41	3.21 ± 0.28	0.58 ± 0.41	.160
30	3.71 ± 0.31	2.95 ± 0.31	0.77 ± 0.33	.021
32[a]	3.68 ± 0.30	2.92 ± 0.32	0.76 ± 0.33	.021
40	3.53 ± 0.27	2.83 ± 0.37	0.70 ± 0.36	.050
50	3.44 ± 0.26	2.87 ± 0.42	0.57 ± 0.39	.148
60	3.43 ± 0.26	2.72 ± 0.50	0.71 ± 0.48	.135

Note. EPDS = Edinburgh Postpartum Depression Scale.
a. Vitamin D insufficiency.

Limitations and Future Studies

This study was carried out using a small convenience sample of women and confounding factors such as a woman's sense of self-esteem, whether she feels she has an adequate support system and coping mechanisms, and whether or not she has or is experiencing stressful life events were not taken into account in the model. A screening instrument was used to assess a woman's risk of having postpartum depression, and ideally in future studies, a follow-up evaluation confirming the diagnosis of postpartum depression should be conducted by a mental health care professional. Future studies should include larger samples so that a larger group of depressed women can be compared with a group of nondepressed women.

Conclusion

This exploratory study demonstrated that vitamin D, measured using serum 25(OH)D, was associated with increased depressive symptoms in postpartum women. The results of this study showed a significant longitudinal relationship between low vitamin D levels and high EPDS scores, warranting future rigorous research with larger sample sizes and other confirmatory methods of diagnosing postpartum depression while controlling for confounding variables.

Declaration of Conflicting Interests

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