Prevalence of Vitamin D Deficiency and Supplementation in Hispanic Breastfeeding Infants:

Evidence-Based Practice

Diane E. Mosqueda

Texas Woman’s University
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Impact of Vitamin D deficiency in Infants: Evidence-Based Practice

Vitamin D deficiency in infants has been receiving much attention in the literature lately. Vitamin D plays an important role in the skeletal development and bone mineralization of a growing infant. Adequate vitamin D status is important during infancy to promote optimal skeletal development. Vitamin D is known as the sunshine vitamin because vitamin D in the presence of sunlight can be synthesized in the skin. However, most babies are often shielded from the sunlight due to their delicate skin. Also babies that have darker skin have been found to be more vitamin deficient due to the deeper pigmentation that does not allow for absorption of the ultraviolet light and therefore dark skin synthesizes less vitamin D (Ninger, 2009). Other sources of Vitamin D are through dietary sources or by supplementation and infants receive vitamin D either by breast milk or formula. Vitamin D deficiency results from an inadequate mineralization or demineralization of the skeleton and in infants this results in rickets (Elias, 2006). Rickets is characterized by slow closing of the fontanels and failure of leg bones to mineralize resulting in bowed or knocked knees (Elias, 2006).

Many families are being challenged in today’s recession and economic woes and the pressure to adequately feed their babies by breastfeeding can be an incentive for mothers who choose this option since formula prices are rising and becoming more expensive. Breastfeeding is considered a healthy option for babies, formula recipes tries to mimic the ingredients found in breast milk. However, one ingredient, vitamin D has been found to be lacking in breast milk may seriously affect the growth and development of the infant. The vitamin D content of human milk is related to the lactating mother’s vitamin D status (Hollis & Wagner 2006). Cancela, LeBoulch and Miravet (1986) found in their study that there is decreased vitamin D content in milk from
woman who themselves are deficient. In 2003, the AAP published its 2003 vitamin D supplementation statement recommending that all breastfed infants start to receive 200 IU of vitamin D per day within the first 2 months after delivery. Subsequently after many studies the AAP published in 2008 vitamin D supplementation statement recommending that all breastfed infants to receive 400 IU of vitamin D per day within the first days of life. The AAP further recommending supplementing partially breastfed infants and formula fed infants not receiving at least 1 liter/day of formula.

**Purpose**

The purpose of this evidenced-based project is to investigate the current literature related to vitamin D deficiency in infants, impact of vitamin D deficiency on infant growth and development, the adverse effects of vitamin D deficiency in infants. The question that is being actively pursued in this evidenced based paper is what are the prevalence of vitamin D deficiency and the use of vitamin D supplementation in healthy Hispanic breastfed infants in Houston, Texas?

**Justification**

**Prevalence of Vitamin D Deficiency**

Vitamin D deficiency rickets occurs in growing children who are typically vitamin D deficient for many months before a clinical diagnosis is made. In the United states, rickets occurs most commonly between the ages of 6 and 18 months and is rarely reported in children older than 5 years of age (Weisberg, Scanlon, Li, & Cogswell, 2004). The United States does not have a mandatory national reporting system for this diagnosis (Greer, 2008). According to Greer (2008) the basis of the number of rickets case reports in the US literature in the past 15 years, the
diagnosis of rickets is becoming more common. However the vast majority of these cases occur in children from ethnic minority groups, especially African American infants whose mothers breastfeed them exclusively without giving them vitamin D supplements (Greer, 2008).

In North Carolina, Kreiter et al., (2000) reported 30 cases of rickets in breastfed African American infants between 1990 and 1999, including 17 cases reported between 1998 and 1990. This increasing number of rickets cases from North Carolina corresponded with an increase in breastfeeding ignition rates from 5.25 to 34.7% between 1988 and 1998 in the North Carolina Women, Infants, and Children clinics (Kreiter et al., 2000). According to Kreiter et al. (2000), reported that 166 cases of vitamin D deficiency rickets in US children younger than 5 years between 1986 and 2003 and of these children, 83% were African American, and 96% were breastfed.

In Texas, McGanity (1969) found in the Nutrition Survey in Texas that 2% of the indigent children had clinical rickets. Nichols, Montandon and Potts (1970) found 4 carefully documented cases of nutritional rickets studied in Houston at Texas Children’s Hospital. Despite the recommendations issued by the AAP for vitamin D supplementation, there is a continued problem of rickets in north (Shah, Patterson, & Seikaly, 2000).

According to Stein (2009) an analysis of federal data released showed 9% of children ages 1 through 21 are deficient in vitamin D while another 61% have higher levels that still are considered insufficient. Lower levels were more common among girls, adolescents and people with darker skin, the study in Pediatrics found. The researchers said unhealthy lifestyles that include too much time indoors watching TV or playing video games likely contribute to the low vitamin D levels. The analysis and an accompanying federal study also found an association
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between low Vitamin D levels and increased risk for high blood pressure, high blood sugar, and a condition that increases the risk for heart disease and diabetes, known as the metabolic syndrome. The studies provide new evidence that low Vitamin D levels may be putting a generation of children at increased risk for heart disease and diabetes, two of the nation's biggest health problems that are also increased by the childhood obesity epidemic (Stein, 2009).

**Prevalence of supplement use**

The use of vitamin D supplementation in children was studied by Yetley (2008), and she reported that in the NHANES (1999-2002) study, the percentage of children taking vitamin D-containing supplements raged from 9% for children younger than 1 year of age to 36% for children aged 4-8 years of age. The prevalence of vitamin D supplement use was 33% in children aged 1-3 years, 23% in those aged 9-13 years, and 16% in adolescents aged 14-18 years. Non-Hispanic white children had a higher prevalence of use (31%) than did non-Hispanic blacks (16%) and Mexican American children (19%). Children classified as being underweight or at risk of underweight had a higher prevalence of use of vitamin D-containing supplements (30% for underweight children, 32% for children at risk of underweight) than did children classified as probably being at a healthy weight (28%), at risk of overweight (23%), or overweight (20%)(Yetley, 2008).

**Definition of Terms**

For the purposes of this project the following terms were defined: Vitamin D, Vitamin D requirements in infants, Vitamin D deficiency in infants, adverse effects of vitamin D deficiency: rickets.
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Vitamin D

Vitamin D is a fat-soluble vitamin that includes both ergocalciferol (obtained from foods) and cholecalciferol (formed by exposure of skin to sunlight) according to Abrams, Pennington, and Lammon (2009). Abrams, Pennington, and Lammon (2009) further explain that vitamin D functions as a hormone and plays an important role in calcium and bone metabolism. The main action of vitamin D is to raise serum calcium levels by increasing intestinal absorption of calcium and mobilizing calcium from bone. Vitamin D is not physiologically active in the body. It must be converted to an intermediate metabolite in the liver, then to an active metabolite (1,25-dihydroxyvitamin D or calcitriol) in the kidneys (Abrams, Pennington & Lammon, 2009).

Vitamin D requirements in infants

AAP published in 2008 vitamin D supplementation statement recommending that all breastfed infants to receive 400 IU of vitamin D per day within the first days of life.

Vitamin D Deficiency in infants

Serum 25-hydroxycholecalciferol concentrations 25-(OH) D is considered as the best index of vitamin stores. Signs of vitamin D deficiency are usually not seen when levels are about 10 ng/ml however many experts considered vitamin D deficiency to be 20 ng/ml (50 nmol/l) (Wagner & Greer, 2008)

Adverse Effects of Vitamin D deficiency: Rickets

Vitamin D deficiency in children is also known as infantile or nutrition rickets. It is characterized by deformities of the skeleton. Symptoms typically associated with vitamin D deficiency rickets include stunted growth, a protruding abdomen, and muscle weakness, enlarged ends of long bones and ribs, and abnormally shaped thorax, and legs that are bowlegged or
knock-kneed. The skull is frequently soft and enlarged with delayed closure of the fontanels (Porth, 1994).

Methodology

A review of the literature was obtained using the Texas Woman’ University library database search engine. The databases accessed were CINAHL with full text database, Medline with full text database, Uptodate, Cochrane Library, and Ovids EBMR Service, Proquest Nursing & Allied Health Source. The keywords used for the database searches were: Vitamin D deficiency, Breastfeeding infants, rickets, vitamin D supplementation, and Vitamin D requirements for infants. Using the keywords for the data search produced over 6,927 articles. Selecting keywords of breastfeeding infant, vitamin D deficiency, or rickets, it was reduced to 1,029 articles. Articles that were not included in the review of literature were due to other findings not being researched in this evidenced based paper. Also additional articles were obtained from the reference lists of relevant articles. Therefore evidence-based journals (synopses), syntheses, and studies were utilized for this literature review.

Review of the Literature

Vitamin D deficiency in infants

Gordon et al. (2008) studied the prevalence of vitamin D deficiency in infants and toddlers. The authors studied 380 children from 8 to 24 months of age at a primary care clinic in Boston over two years. The study was a cross-sectional sample. The populations in the study were primarily African American and Latino and approximately 25% of parents were immigrants from diverse regions. The data collected from this study were clinical and anthropometric data, administered parental nutritional and lifestyle questionnaires, and obtained blood samples to
measure 25-hydroxyvitamin D (25OHD) level. For the purpose of the study a vitamin D level of 20 ng/ml was considered a marker for vitamin D deficiency. The patients were divided into 3 diagnostic categories according to serum 25OHD levels: vitamin D deficiency (<20 ng/ml), severe vitamin D deficiency (<8ng/ml), and suboptimal vitamin D status (30ng/dl). Of the 380 children, the actual data was obtained from 365 children, 44 (12.1%) were found to be vitamin D-deficient, with 7 (1.9%) severely deficient (<8ng/ml). Also, 146 children in the study (40%) had vitamin D levels below the accepted threshold (<30 ng/ml). The prevalence of vitamin D deficiency was the same in infants and toddlers. Gordon et al. (2008) found that the prevalence of deficiency did not vary by sex, season, time spent outdoors, sunscreen use, sun sensitivity, or skin pigmentation. Infants that were breastfeeding without vitamin D supplementation markedly increased the odds of vitamin D deficiency compared with exclusive bottle feeding (only 2% of breastfed infants were receiving vitamin D supplementation). Strength of Evidence = 2b

Individual cohort with < 80% follow-up.

Peng and Serwint (2003) studied breastfed children with nutritional rickets during and after the first year of life. The study was conducted from 1990-2000 in Baltimore Maryland. There were 30 patients all who were African American. Patients 12 months or younger (n=15) compared to those older than 12 months (n=15) were more likely to be born during the summer and present with seizures and hypocalcaemia. The study design was a retrospective chart review. Medical records were obtained from both outpatient and inpatient settings. The children that were included in the study were breastfed and were diagnosed with nutritional rickets. The cases were defined by radiographic findings consistent with rickets and exclusion of other possible causes of rickets. The findings of the study demonstrated that infants with rickets are more likely
to be born during the summer and to present with seizures and hypocalcaemia. The infants born in the summer had lower vitamin D levels at 6 months of age while those born in the winter months had higher levels at 6 months of age. The study was limited due to difficulty in quantifying sun exposure or determining skin color. The Strength of evidence = 4 poor quality cohort.

Spence and Serwint (2004) report a case of subclinical vitamin D deficiency rickets. A 9 month old African American male present to a clinic and was exclusively breastfed until 6 months of age and by 9 months he was breastfeeding on demand and eating infant cereal, fruits, vegetables, and table foods but had not received supplementation of vitamin D. The child was found to be vitamin D deficient, the 25-hydroxyvitamin D level = 18 ng/ml (a level < 20 ng/dl is considered a deficient status). Radiographs of the left wrist and left knee revealed changes consisted with rickets such as metaphyseal flaring, irregularity, and widening of the physes without evidence of fracture (Spence & Serwint, 2004). The child was began vitamin D supplementation and 4000 IU of ergocalciferol (Vitamin D3) per day and after 3 months of treatment, his laboratory results normalized. Spence and Serwint (2004) conclude that secondary prevention includes detecting and treating subclinical rickets before it progresses to clinical rickets and further suggest that there is a lack of studies supporting purposeful screening for subclinical rickets. Therefore, it is important to screen for subclinical vitamin D deficiency rickets in inadequately supplemented infants by using wrist radiographs paired with 25-hydroxyvitamin D levels while further improving primary prevention strategies. Strength of evidence = 5 as the article expert opinion without critical evaluation.
Interventions for the prevention of nutritional rickets in term born children a systemic review by the Cochrane Library was reviewed. Leech and Meissner (2009) reviewed studies that included randomized controlled clinical trials, controlled clinical trials or prospective cohort studies comparing any intervention for the prevention of nutritional rickets in term born children with placebo or no intervention. The minimum duration of the intervention was three months for children under 12 months or six months of children over 12 months. There were four studies that enrolled 1700 children and the trials lasted between nine months to two years. Three studies were randomized controlled trials and two were a cluster-randomized design: one trial probably was a controlled trial with researcher controlled group assignment. Only one study investigated the adverse effects of supplementation are hypercalcemia or nephrocalcinosis and overexposure of the skin to sunlight that may lead to skin cancer. In two studies conducted in older children in China and in France no rickets occurred in both the intervention and control group. Leech and Meissner (2009) concluded that there are only a few studies on the prevention of nutritional rickets in term born children. The authors recommend preventive measures (vitamin D or calcium) to groups of high risk, like infants and toddlers; children living in Africa, Asia, or the Middle East or migrated children from theses regions into areas where rickets is not frequent. The authors further conclude that new studies investigating main and side effects of preventive measure against nutritional rickets in different age groups and in different countries are indicated (Leech & Meissner, 2009). Strength of evidence = 2a groups were randomly allocated into an experimental and a control group but there existed researcher bias in one study the researcher assigned the groups.
Vitamin D effects on maternal and breastfed infants

Hollis and Wagner (2004) examined the effect of high-dose maternal vitamin D2 supplementation on the nutritional vitamin D status of mothers and nursing infants. Fully lactating mothers (n=18) were enrolled at 1 month after birth to 1 of 2 treatments arms: either 1600 IU vitamin D2 and 400 IU vitamin D3 (prenatal vitamin) or 3600 IU vitamin D2 and 400 IU vitamin D3, for a 3 month study period. The subjects were randomly divided into 2 groups. The study was a randomized controlled trial and each subject served as her own control: the vitamin D status at 1 month was compared with values at 3 additional time points. The subjects were instructed to limit sun exposure (for mother and infant). Blood, urine, and milk samples were obtained from the mothers at months 1, 2, 3, and 4 of lactation. Infant blood was collected at months 1 and 4. Maternal serum was monitored for total calcium, vitamin D2, vitamin D3, 25(OH)D2 and 25(OH)D3 concentrations. Infant serum was monitored for vitamin D2, vitamin D3, 25(OH)D2, 25(OH)D3, calcium, and phosphorus concentrations. The mother’s urine was monitored for calcium/creatinine ratio. Vitamin D antiachitic activity in mother’s milk was also measured. Vitamin D2 was used as a tracking agent for maternal dosing because the contribution of vitamin D2 from other sources would be unlikely. The results of this study showed that the antiachitic activity of milk from mothers receiving 2000 IU/d vitamin D increased by 34.2 IU/L., on average, whereas the activity in the 4000 IU/d group increased by 94.2 IU/L. Nursing infant circulating 25(OH)D2 concentrations reflected maternal intake and the amount contained the milk. With limited sun exposure, an intake of 400 IU/d vitamin D would not sustain circulating 25(OH)D concentrations and thus would supply only limited amounts of vitamin D to nursing infants in breast milk. A maternal intake of 2000 IU/d vitamin D would elevate circulating
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25(OH)D concentrations for both mothers and nursing infants. A maternal intake of 4000IU/d could achieve substantial progress toward improving both maternal and neonatal nutrition vitamin D status. Hollis and Wagner (2004) conclude that the current DRI of 400 IU/d vitamin D for lactating mothers is irrelevant to the vitamin D status of mothers and nursing infants. Maternal vitamin D intakes of >4000IU/d appear to be safe and to provide sufficient vitamin D to ensure adequate nutritional vitamin D status for both mother and breastfed infants. The recommendations from this study indicated that further studies need to look at the impact of sun exposure or lack of it for both mother and baby (Hollis & Wagner, 2004). The strength of evidence = 2a, this was a pilot study and tested on a small individual cohort and no long term data was collected.

Lee et al. (2007) measured 25(OH)D in 40 healthy, mostly African American mother-infant pairs. The study was a cross-sectional design, which consisted of a convenience sample of mother-infant pairs recruited from the maternity floor of Boston Medical Center from October 2002 to February 2003. Venous blood was drawn from the mother and the infant for a plasma 25(OH)D concentration 24 to 48 hours after birth. The majority of these mothers received a daily prenatal multivitamin (ingesting between 400 and 600 IU vitamin D a day and drank on average, 2 glasses of milk a day) vitamin D deficiency (<30 nmol/L) was found in 50% of mothers (n=20) and 65% of their newborn infants (n=26). There was a positive correlation between maternal and infant plasma 25(OH) D concentrations. Lee et al (2007) conclude that there is a high prevalence of vitamin D deficiency in African American mothers and their infants in the perinatal period. It was also found that the low vitamin D stores at birth might be another important risk factor for development of rickets in African American infants. Strength of
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evidence = 2b because it is an individual cohort study but a convenience sample and no indication of a blinded study.

**Vitamin D requirements for Infants**

Greer (2008) reviewed studies that looked at serum 25-hydroxyvitamin D -25(OH) D concentrations and functional outcomes of vitamin deficiency in young children and breastfed and non-breastfed infants. The author reviewed the outcomes that included the presence or absence of vitamin D deficiency rickets, bone mineral content, and serum parathyroid hormone concentrations. He concluded that daily vitamin D supplements of 400 IU/L keep serum 25(OH) D concentrations higher than 50 nmol/L and prevent rickets in infants and young children. He also concluded that there is not enough evidence in the studies to support the use of bone mineral content or parathyroid hormone concentrations in infants and young children as function outcomes to define deficiency or sufficient levels of 25 (OH) D. Strength of evidence =3a systematic review (with homogeneity) of case- controlled studies.

According to Henderson (2005), a typical infant who is breastfeeding will consume approximately 750 ml/day and that human breast milk only contains about 10-60 IU/L of Vitamin D. Therefore a breastfeeding baby who is not supplementing with formula will run the risk of being vitamin D deficient. Strength of evidence = 5 as the article expert opinion without critical evaluation.

Phinney (2008) reviewed studies that reported discrepancies between the results of assays used to measure 25 (OH) D assays to reflect accurately the vitamin D status of individuals. The National Institute of Standards and Technology has been working with the National Institutes of Health’s Office of Dietary Supplements to develop a standard reference material for circulating
vitamin D analysis. She concludes that this standard reference material will provide a material with stable well-defined levels of the analytes of interest (Phinney, 2008). Therefore investigators will be able to use the standard reference material to validate new analytic methods for vitamin D measurements. Strength of evidence = 5 as the article expert opinion without critical evaluation.

**Vitamin D and Current Practice**

The current recommendations for vitamin D supplementation for breastfed infants were published by the AAP in 2003 for 200 IU of Vitamin D per day. However the reports of vitamin D deficiency rickets have been rare in the United States, but over the last few years there has been an increase (Shaikh & Alpert, 2004). According to Davenport, Uckin and Calikoglu (2004), a questionnaire was mailed to all active members of the North Caroline Chapter of American Academy of Pediatrics (AAP) in October, 1999 to determine their vitamin D supplementation practices (n=1040). Of the 1040 questionnaires, 417 (40.1%) were returned, and 383 were suitable for analysis. Most of the participants were primary care physicians (86.4%) and practiced in private offices (68.1%). They averaged 19.2 +10.4 years of experience. Of these, 25.8% reported seeing >1 cases of vitamin D deficiency rickets within the previous 3 years. Some (13%) of the physicians never recommended vitamin D supplementation and few (9%) always recommended supplementations. Most, however, recommended supplementation for selected groups (for example, breastfed, dark-skinned, premature, or undernourished infants). The respondents (44%) recommended vitamin D supplements for all breastfed infants, and (38.6%) recommended it for some, and 16.5% never recommended it. The majority of pediatricians that did not recommend vitamin D supplementation for breastfed infants (83.1%)
believed that human milk already has sufficient vitamins. Others were concerned about the cost (3.1%), the risk of hypervitaminosis (4.2%), decreasing the likelihood of breastfeeding (2.1%) or other problems (14.7%). Strength of evidence = 4

Shaikh and Alpert (2004) described the vitamin D recommendation practices among pediatric health care providers in Las Vegas, Nevada. This study was a cross-sectional survey of pediatricians, family physicians, and nurse practitioners practicing general pediatrics more than 10% of their time in outpatient clinics (n=155). The survey was a two page, self-administered questionnaire that took approximately 5 minutes to complete. The information obtained assessed the practitioners’ knowledge of about vitamin D deficiency, rickets in which the participants could either agree or disagree. Additional information concerning vitamin D supplementation, reasons for supplementing or not supplementing was also elicited. The babies whose diets consisted of only maternal breast milk and no infant formula or solid food were considered. Seventy-four (47.7%) providers recommended the supplementation of exclusively breastfed infants with vitamin D, and 81 (52.3%) did not. Forty-two (27.1%) providers’ additionally supplemented babies fed both breast milk and infant formula with vitamin D. It was also interesting that the providers who recommended vitamin D supplementation were more likely to be female and Hispanic, to have graduated from training 21 or more years previously. Almost 10% of providers had encountered a total of 41 clinical cases of rickets in the total time they had practiced pediatrics. There was an open-ended question as to why providers did not recommend vitamin supplements, common responses were that “Las Vegas had abundant sunshine” (11.7%), “rickets was very rare” (6.7%), “breast milk had adequate amounts of vitamins” (3.3%), and
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“supplementing with vitamins was not cost effective” (1.7%) (Shaikh & Alpert, 2004) Strength of evidence = 3b and individual case control study.

Conclusion

Vitamin D deficiency rickets has been diagnosed as early as 1650 and is characterized by deformities of the skeleton and generalized muscle weakness, and has been observed in children around the world (Henderson, 2005). In the United States rickets had been on the decline by the 1960’s with the implementation of vitamin D fortification of milk products and infant formula, however with the increase of breastfeeding practices there has been a subsequent increase in reports of vitamin D deficiency rickets (Henderson, 2005). Vitamin D deficiency rickets in infants can have multiple problems such as muscle weakness, stunted growth, enlarged ends of long bones and ribs, poor dentition, and delayed motor development. Other serious issues can also arise due to vitamin D deficiency such as muscle cramps, parenthesis, seizures, numbness, and laryngospasm (Henderson, 2005). There is a paucity of studies of the breastfed Hispanic infant and the prevalence of vitamin D deficiency. Due to cultural practices of Hispanics, such as covering and shielding the infant from sunshine, and also the economic strain on the family and lack of resources (many undocumented Hispanic mothers are reluctant to seek public services such as WIC), Hispanic infants can be more vulnerable to vitamin D deficiency. The implications of findings on changes in nursing practice was found in some of the studies that there continues to exist myths associated with Vitamin D supplementation for the breastfed infant particularly in communities that have abundant sunshine (Shaikh & Alpert, 2004). Some practitioners still do not provide supplementation for breastfed infants either because the mother
was supplementing with infant formula or an assumption that the breast milk was sufficient with vitamin D.
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