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VITAMIN D SUPPLEMENTATION IN BREASTFEEDING WOMEN AND VITAMIN D STATUS IN INFANTS – A REVIEW OF CURRENT CLINICAL STUDIES

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ABSTRACT

Background: Vitamin D deficiency is a major public health concern, particularly among breastfed infants, whose vitamin D status depends largely on maternal 25-hydroxyvitamin D [25(OH)D] levels during pregnancy and lactation. Maternal supplementation has been proposed as a strategy to improve infant vitamin D status.
Objective: This review aimed to evaluate the effect of vitamin D supplementation in breastfeeding women on 25(OH)D concentrations in exclusively breastfed infants.
Materials and Methods: A narrative review of randomized controlled trials published between 2015 and 2025 was conducted. Ten studies assessing maternal vitamin D supplementation and its impact on infant 25(OH)D levels were included.
Results: Maternal supplementation increased 25(OH)D levels in both mothers and infants. However, standard doses (400–800 IU/day) were often insufficient to achieve adequate vitamin D status in infants. Higher doses, particularly ≥4000 IU/day, resulted in significant improvements and, in some cases, achieved levels comparable to direct infant supplementation.
Conclusions: Vitamin D supplementation in breastfeeding women may effectively improve infant vitamin D status, especially at higher doses. However, its efficacy depends on dosage, and further research is needed to determine optimal and safe supplementation strategies.

KEYWORDS

Vitamin D Supplementation; Lactating Mothers; Breastfeeding; Infant Vitamin D Status; 25-Hydroxyvitamin D; Randomized Controlled Trial

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Introduction

Vitamin D plays a key role in maintaining calcium-phosphate homeostasis and proper bone mineralization, particularly during periods of rapid growth and development [21,23]. In addition to its classic role in regulating bone metabolism, it also exhibits a range of pleiotropic effects, including influences on the immune system, metabolic functions, and inflammatory processes [21,23]. In recent years, there has been growing interest in the importance of vitamin D during pregnancy and lactation, due to its potential impact on the health of the mother and the developing child [22].

Vitamin D deficiency remains a significant public health problem worldwide, affecting both developed and developing countries [17,18,19,32]. It is estimated that a significant proportion of women of childbearing age have insufficient levels of 25-hydroxyvitamin D [25(OH)D], which may have significant consequences for pregnancy outcomes and neonatal health [17,18,27,32]. Deficiency of this vitamin has been associated with, among other things, low birth weight, increased risk of infection, skeletal development disorders, and a higher risk of chronic diseases later in life [1,20,23,24].

During lactation, the need for vitamin D remains high, and an adequate intake is essential for both the health of the nursing mother and the proper development of the infant. Vitamin D present in breast milk is one of the main sources of this vitamin for exclusively breastfed infants; however, its concentration in breast milk is typically low and depends on the mother's vitamin D status [21,27,2,4].

Exclusively breastfed infants are at particularly high risk of vitamin D deficiency, especially in settings with limited exposure to sunlight [4,29]. For this reason, routine vitamin D supplementation for infants is recommended in many countries as a primary strategy for preventing deficiency [16]. An alternative approach is vitamin D supplementation in breastfeeding women, which may increase the vitamin's concentration in breast milk and thereby improve its supply to the infant [21,27,31,3].

Despite the availability of numerous studies on vitamin D supplementation during lactation, there remains disagreement regarding optimal supplementation doses and the effectiveness of various strategies for preventing vitamin D deficiency in breastfed infants. In particular, it is not clear whether maternal supplementation can serve as an equivalent alternative to direct supplementation of the infant.

The aim of this review was to compare the effectiveness of various vitamin D supplementation strategies during lactation, with a particular focus on the impact of maternal supplementation on vitamin D status in breastfed infants.

Methodology

This review is narrative in nature and involves an analysis of available randomized controlled trials (RCTs) evaluating the effect of vitamin D supplementation in breastfeeding women on the vitamin D status of exclusively breastfed infants. To ensure transparency in the study selection process, elements of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were applied [33].

A literature search was conducted in the PubMed (MEDLINE) database through January 2026. The search identified publications meeting the thematic criteria; after reviewing the titles and abstracts, articles were selected for full-text evaluation, and ultimately, 10 studies meeting all inclusion criteria were included in the review. Publications published in English between 2015 and 2025 were included. The search strategy included combinations of keywords such as: “vitamin D,” “lactation,” “breastfeeding,” “maternal supplementation,” “infant vitamin D status,” and “randomized controlled trial.” Additionally, the reference lists of selected publications were reviewed to identify additional studies meeting the inclusion criteria.

The review included studies that met the following criteria: (1) randomized study design, (2) participation of breastfeeding women and their infants, (3) assessment of the effect of maternal vitamin D supplementation on 25-hydroxyvitamin D [25(OH)D] in the infant, (4) a clearly defined supplementation dose and duration of the intervention. Observational studies, systematic reviews and meta-analyses from the main analysis and studies not meeting the above criteria were excluded; review publications were used only for background and context.

The analyzed studies included various vitamin D supplementation regimens, which were divided into three main groups: low doses (400–800 IU/d), moderate doses (800–4000 IU/d), and high doses (≥4000 IU/d). This division allowed for a comparison of the effectiveness of individual supplementation strategies and an assessment of the relationship between vitamin D dose and 25(OH)D concentration in infants [21,31].

Additionally, the influence of factors such as supplementation duration, maternal baseline vitamin D status, and environmental factors, including solar radiation exposure and geographical latitude, which may significantly influence supplementation efficacy, was analyzed [32].

Due to the heterogeneity of the analyzed studies, including differences in study populations, supplementation doses, and intervention duration, a meta-analysis was not performed. Results were presented as a qualitative comparative analysis, focusing on the direction and magnitude of the observed supplementation effects.

The Role of Vitamin D during Lactation

Vitamin D plays a significant role in regulating calcium and phosphate metabolism and bone mineralization, which is particularly important during the period of intensive growth and development of infants [21,23]. In addition to its classic effects on bone metabolism, it also exhibits numerous pleiotropic effects, including influence on immune system function, regulation of inflammatory processes, and cellular metabolism [21,23].

In the human body, vitamin D can be synthesized in the skin under the influence of UVB radiation or obtained from diet and supplements. It is then hydroxylated in the liver to 25-hydroxyvitamin D [25(OH)D], which is the main marker of vitamin D status, and then in the kidneys to the active form – 1,25-dihydroxyvitamin D [1,25(OH)$_2$D] [21,23]. Serum 25(OH)D concentration is considered the most reliable indicator of vitamin D status [31].

During lactation, the relationship between maternal vitamin D status and its content in human milk is particularly important. It has been shown that the concentration of 25(OH)D in the serum of a breastfeeding woman directly influences the amount of vitamin D transferred to the infant in milk [21,27]. However, the natural content of vitamin D in human milk is usually insufficient to meet the infant's requirements, especially in cases of low maternal vitamin D status [21,26,31,4].

Consequently, exclusively breastfed infants are a group particularly vulnerable to vitamin D deficiency, especially in conditions of limited exposure to solar radiation [29]. Vitamin D deficiency in this age group may lead to bone mineralization disorders, including rickets, and may also affect the development of the immune system [28].

Environmental conditions and lifestyle are also important factors influencing vitamin D status in mothers and children. Exposure to solar radiation, latitude, season, and sunscreen use can significantly limit cutaneous vitamin D synthesis, contributing to an increased risk of vitamin D deficiency [28,32].

In recent years, there has been increasing interest in the strategy of vitamin D supplementation in breastfeeding women as a potential method to improve vitamin D status in infants. Research results indicate that increased maternal vitamin D supply can lead to a significant increase in 25(OH)D concentrations in both maternal serum and breast milk, which translates into improved vitamin D status in the child [21,31].

Despite the growing number of studies in this area, discrepancies remain regarding the optimal doses of vitamin D supplementation in breastfeeding women and the effectiveness of this strategy compared to direct supplementation of infants. Therefore, further research is needed to clearly define the most effective supplementation regimens during lactation [21].

Results

A total of 10 randomized controlled trials assessing the effect of vitamin D supplementation in breastfeeding women on 25-hydroxyvitamin D [25(OH)D] concentrations in breastfed infants were included in the analysis.

Effects of Vitamin D Supplementation at Doses of 400–800 IU/day

An analysis of available randomized controlled trials indicates that vitamin D supplementation in breastfeeding women at doses of 400–800 IU/day leads to a moderate increase in maternal serum 25-hydroxyvitamin D [25(OH)D] concentrations [5,6,8,9]. Most of the analyzed studies observed improved vitamin D status in women, but this effect did not always translate into optimal 25(OH)D concentrations in exclusively breastfed infants.

Clinical studies have shown that despite standard doses of maternal supplementation, infant 25(OH)D concentrations often remained below those considered adequate, suggesting limited effectiveness of this strategy in improving childhood vitamin D status [8,9]. These results indicate that the amount of vitamin D transferred into breast milk at low doses of supplementation may be insufficient to meet infant requirements.

Consequently, exclusively breastfed infants may be at increased risk of vitamin D deficiency, especially in conditions of limited exposure to sunlight and low initial maternal vitamin D status [29]. Environmental factors such as latitude, season, and lifestyle may further influence the effectiveness of supplementation and exacerbate the risk of deficiency [28,32].

An important element in the interpretation of results is the relationship between the initial maternal 25(OH)D concentration and the effectiveness of supplementation. In populations where vitamin D deficiency is observed in lactating women, standard supplementation at doses of 400–800 IU/day may not achieve optimal concentrations of this vitamin in either the mother or the child [25,26].

In summary, vitamin D supplementation in breastfeeding women at doses of 400–800 IU/day may be sufficient to maintain the mother's baseline vitamin D status, but its effectiveness in improving 25(OH)D concentration in exclusively breastfed infants remains limited. The results of the analyzed studies indicate the need to consider higher doses of supplementation in mothers or parallel supplementation of infants as a more effective strategy for preventing vitamin D deficiency [21].

Effects of Vitamin D Supplementation at Doses of 800–4000 IU/day

An analysis of randomized controlled trials indicates that vitamin D supplementation in breastfeeding women at doses of 800–4000 IU/day leads to a more significant improvement in 25-hydroxyvitamin D [25(OH)D] concentrations in both mothers and their infants compared to standard supplementation doses [5,6,7,11,21]. These results suggest that increased vitamin D intake during lactation may more effectively influence the vitamin D status in the mother-child relationship.

Clinical studies have shown that the use of intermediate doses was associated with an increase in 25(OH)D concentration in breastfeeding women and improved vitamin D status in exclusively breastfed infants [5,6,7]. Compared to lower doses of supplementation, this effect was more pronounced, which may indicate that the amount of vitamin D transferred into breast milk with supplementation in this range is more similar to the infant's requirements.

The duration of supplementation may also be important. Some studies have observed that longer-term interventions led to a more stable increase in 25(OH)D concentrations in both mothers and their children, suggesting that the effectiveness of supplementation depends not only on the dose but also on the duration of its use [5,6]. At the same time, it is important to consider that the response to supplementation may be modified by baseline vitamin D status, lifestyle, and exposure to sunlight [32].

Available studies indicate that vitamin D supplementation at doses of 800–4000 IU/day may be a more effective strategy for improving vitamin D status in infants than standard supplementation. At the same time, these doses seem to represent a compromise between the efficacy and safety of supplementation, especially in populations at increased risk of vitamin D deficiency [21,30].

In summary, vitamin D supplementation in breastfeeding women at doses of 800–4000 IU/d leads to a more significant improvement in 25(OH)D concentrations in mothers and their infants than doses of 400–800 IU/d. The results of the analyzed studies suggest that this dose range may be more effective in preventing vitamin D deficiency in exclusively breastfed infants, although its effectiveness depends on the duration of supplementation, initial vitamin D status and environmental factors [21,25].

Effects of High-Dose Vitamin D Supplementation (≥4000 IU/day)

Analysis of randomized controlled trials indicates that high-dose vitamin D supplementation in breastfeeding women (≥4000 IU/day) leads to a significant increase in 25-hydroxyvitamin D [25(OH)D] concentrations in both mothers and their infants [8,10,11,12,13,14]. Compared to lower doses of supplementation, this effect is more pronounced and, in many cases, allows 25(OH)D concentrations in infants to be achieved within the range considered normal.

Clinical studies have shown that the use of high doses of vitamin D in breastfeeding women leads to a significant increase in the content of this vitamin in breast milk, which translates into effective transfer of vitamin D to the child [10,11,12,13,14,15]. Some studies have observed that this strategy may be comparable in effectiveness to direct supplementation of infants, indicating its potential use as an alternative approach to the prevention of vitamin D deficiency.

At the same time, the effectiveness of high-dose supplementation may be modified by factors such as the mother's baseline vitamin D status, duration of supplementation, and environmental factors, including solar exposure and latitude [32]. In populations with high rates of vitamin D deficiency, the effects of supplementation may be particularly pronounced.

Another important aspect of the analyzed studies is the safety of high-dose vitamin D supplementation during lactation. Most studies did not observe significant adverse effects associated with supplementation, even at doses exceeding standard preventive recommendations [12,15,30]. These results suggest that high-dose vitamin D supplementation may be safe with appropriate clinical monitoring.

In summary, vitamin D supplementation in breastfeeding women at doses ≥4000 IU/day is the most effective among the strategies analyzed in improving vitamin D status in infants. It may be an effective alternative to direct supplementation of infants, but its use should be individually tailored and take into account potential factors influencing the body's response to supplementation [21].

Analysis of available randomized controlled trials indicates that the effectiveness of vitamin D supplementation in breastfeeding women in improving vitamin D status in infants is clearly dependent on the supplementation dose used.

Additional Characteristics of the Analyzed Studies

The analyzed randomized controlled trials demonstrated significant heterogeneity in terms of intervention duration, participants' baseline vitamin D status, supplementation method, and environmental conditions. These factors may have influenced the observed differences in the effectiveness of vitamin D supplementation in breastfeeding women and their infants.

The supplementation regimens used varied in both the vitamin D dose and the frequency of its administration. Some studies used daily supplementation, while others analyzed weekly or monthly regimens. These differences may be important for interpreting the results of individual studies, as the method of vitamin D administration may influence the dynamics of changes in serum 25(OH)D concentration.

Impact of Supplementation Duration

The duration of supplementation was a key factor influencing the effectiveness of the intervention. In the analyzed studies, the supplementation period typically ranged from several weeks to several months. Some studies demonstrated that longer supplementation durations were associated with more stable and pronounced increases in 25-hydroxyvitamin D [25(OH)D] concentrations in both mothers and their infants [5,6]. Shorter interventions may not have achieved metabolic equilibrium, especially when lower vitamin D doses were used.

The Impact of Baseline Vitamin D Status

Baseline vitamin D status in breastfeeding women significantly influenced the body's response to supplementation. Studies conducted in populations with high rates of vitamin D deficiency observed a more pronounced increase in 25(OH)D concentration in response to supplementation [25,26]. In contrast, in women with normal baseline vitamin D levels, the effect of supplementation was often less pronounced, indicating the importance of individual metabolic conditions and baseline vitamin D deficiency.

Effects of Supplement Administration Method

The analyzed studies used various vitamin D supplementation regimens, including daily administration and higher doses administered weekly or monthly. The method of supplement administration could have influenced the dynamics of changes in serum 25(OH)D concentration, but the available data do not allow for a clear determination of the superiority of one regimen over another [21,31]. It should also be noted that regular supplementation may be crucial for achieving stable therapeutic effects.

Influence of Environmental Factors

Environmental conditions were a significant factor influencing vitamin D status in mothers and infants. Solar exposure, latitude, season, and lifestyle can significantly influence cutaneous vitamin D synthesis [28,32]. Populations living in regions with limited UVB radiation exposure were more likely to have lower baseline 25(OH)D concentrations and a greater reliance on supplementation as the primary source of this vitamin. These factors may partially explain the differences in results across studies.

Safety of Vitamin D Supplementation

The safety of vitamin D supplementation was an important consideration in the studies reviewed. Most randomized, controlled trials did not report significant adverse events associated with vitamin D supplementation, even at doses exceeding standard preventive recommendations [12,15,30]. These results suggest that vitamin D supplementation during lactation may be safe with appropriate clinical monitoring. However, it should be emphasized that the use of high-dose supplementation should be individualized and take into account potential differences in vitamin D metabolism.

Comparison of Supplementation Strategies

Infant Supplementation

Direct vitamin D supplementation in breastfed infants is currently the standard strategy for preventing vitamin D deficiency in many countries. Clinical guidelines recommend routine vitamin D supplementation to infants from the first days of life, regardless of feeding method, to ensure adequate 25-hydroxyvitamin D [25(OH)D] levels and prevent bone mineralization disorders [16].

The effectiveness of this strategy has been confirmed in numerous studies, which have shown that regular vitamin D supplementation in infants leads to maintaining normal serum 25(OH)D concentrations and reducing the risk of developing rickets and other consequences of deficiency [16]. Direct supplementation allows for precise control of the vitamin D dose taken by the child, which is a significant advantage over indirect supplementation methods.

Despite the high effectiveness of this strategy, its limitation may be the requirement for daily administration, which poses a risk of irregular supplementation by caregivers. Some studies have indicated that compliance with supplementation recommendations may be insufficient, which may reduce the effectiveness of vitamin D deficiency prevention.

Additionally, this strategy does not affect the vitamin D status of the breastfeeding woman, meaning that any maternal vitamin D deficiency remains unaddressed. This may be a limitation of this method in the context of a holistic approach to maternal and child health.

In summary, direct infant supplementation is an effective and well-established strategy for preventing vitamin D deficiency, helping to maintain normal 25(OH)D levels in breastfed infants. However, its effectiveness depends on regular use and caregivers' compliance with supplementation recommendations [16].

Maternal Supplementation

Vitamin D supplementation in breastfeeding women is an alternative strategy to prevent vitamin D deficiency in infants, based on increasing the vitamin D content in breast milk. It has been shown that maternal 25-hydroxyvitamin D [25(OH)D] levels directly influence the amount of vitamin D transferred to the infant during breastfeeding [21,27].

Clinical studies have shown that vitamin D supplementation in breastfeeding women leads to increased 25(OH)D concentrations in both maternal serum and breast milk, which translates into improved vitamin D

status in exclusively breastfed infants [10,13,31]. However, the effectiveness of this strategy is strongly dependent on the supplementation dose used. Standard doses may be insufficient, while higher doses are more effective in increasing vitamin D concentrations in children.

A significant advantage of maternal supplementation is the simultaneous improvement of vitamin D status in both the breastfeeding woman and her infant, providing a more comprehensive approach to preventing vitamin D deficiency. This strategy may also eliminate the need to directly administer supplements to the infant, which may improve compliance in some cases.

However, maternal supplementation has certain limitations. The effectiveness of this method depends on the regularity of supplementation by the breastfeeding woman and her baseline vitamin D status. In cases of low baseline 25(OH)D concentrations, higher doses of supplementation may be necessary to achieve optimal results [25,26].

Additionally, the use of high doses of vitamin D in breastfeeding women requires consideration of safety aspects. However, available data indicate that vitamin D supplementation, even at higher doses, is well tolerated and is not associated with a significant risk of adverse effects when appropriate clinical monitoring is followed [12,15,30].

In summary, vitamin D supplementation in breastfeeding women may be an effective strategy for improving vitamin D status in breastfed infants, particularly when appropriately adjusted, higher doses are used. However, its effectiveness depends on many factors, including the supplementation dose, the mother's baseline vitamin D status, and compliance with supplementation recommendations [21,3].

Comparison of the effectiveness of both strategies

Comparison of the effectiveness of the two main strategies for preventing vitamin D deficiency in breastfed infants – direct supplementation of the child and supplementation of the mother during lactation – is an important element in interpreting the available scientific data.

Direct supplementation of infants remains the standard of care in many countries and is highly effective in maintaining normal serum 25-hydroxyvitamin D [25(OH)D] levels in children [16]. This strategy allows for precise control of the infant's vitamin D intake and ensures relatively predictable effects of supplementation.

Vitamin D supplementation in breastfeeding women, in turn, is based on an indirect mechanism of increasing the infant's vitamin D supply through breast milk. Clinical studies have shown that with appropriately high doses of maternal supplementation, it is possible to achieve 25(OH)D concentrations in infants comparable to those obtained with direct supplementation [10,13,21]. However, the effectiveness of this strategy is largely dependent on the supplementation dose and the initial vitamin D status of the breastfeeding woman.

When lower doses of maternal supplementation are used (400–800 IU/d), limited effectiveness in improving vitamin D status in infants is observed, suggesting the advantage of direct supplementation of the child in this situation [5,6,8,9]. However, when higher doses of supplementation are used in breastfeeding women (≥4000 IU/d), the effectiveness of both strategies may be similar, suggesting the possibility of using maternal supplementation as an alternative approach in selected cases [10,11,12,13,14,21].

An important aspect of comparing both strategies is their impact on the vitamin D status of breastfeeding women. Direct supplementation of the infant does not affect the mother's 25(OH)D concentration, whereas maternal supplementation allows for a simultaneous improvement in the vitamin D status of the mother-child system, which may be a significant advantage from the perspective of the woman's health [21,27].

However, the practical aspects of using both strategies must also be considered. Direct supplementation of infants requires systematic administration of the preparation, which may entail the risk of irregular use. Maternal supplementation, on the other hand, requires the use of sufficiently high doses of vitamin D and monitoring of its status, which may limit its use in clinical practice.

In summary, direct supplementation of infants remains the most predictable and well-established strategy for preventing vitamin D deficiency. Maternal supplementation may be an effective alternative, especially when higher doses of vitamin D are used, but its effectiveness is more dependent on individual factors and conditions of use [21].

Discussion

The results of the analyzed randomized controlled trials indicate that vitamin D supplementation in breastfeeding women can improve vitamin D status in both mothers and their infants [21,31]. The data suggest that the effectiveness of this strategy is largely dependent on the dose of supplementation used and its duration [5,6,21]. In particular, a clear relationship is observed between the maternal vitamin D dose and the concentration of 25-hydroxyvitamin D [25(OH)D] in breastfed infants [5,6,7].

Analysis of studies on standard vitamin D supplementation in breastfeeding women (400–800 IU/day) indicates that these doses may be insufficient to ensure adequate 25(OH)D concentrations in exclusively breastfed infants [8,9]. Although improvements in vitamin D status in mothers are observed, the increase in 25(OH)D concentrations in children is usually less pronounced. This suggests that standard preventive doses used in adults do not always ensure an adequate supply of vitamin D transmitted through breast milk [8,9].

Higher doses of supplementation (800–4000 IU/d) resulted in a more pronounced increase in 25(OH)D concentration in both mothers and their infants [5,6,7]. These results indicate that increased vitamin D supply in breastfeeding women may be more effective in improving the vitamin D status in the mother-child relationship. However, it should be emphasized that the effects of supplementation depend on many factors, such as baseline vitamin D status, duration of intervention, and environmental factors influencing skin vitamin D synthesis [32].

The most pronounced effect is observed with high-dose supplementation (≥4000 IU/d) [10–15]. Studies have shown that such doses lead to a significant increase in 25(OH)D concentrations in both women and their children, in many cases enabling the achievement of values considered normal [10–15]. This indicates that appropriately selected maternal supplementation may be an effective alternative to direct supplementation of infants.

An important element in interpreting the results is the comparison of two main strategies for preventing vitamin D deficiency: direct supplementation in infants and maternal supplementation during lactation. Direct supplementation remains the standard of care in many countries and allows for precise control of the child's vitamin D supply [16]. Maternal supplementation, on the other hand, allows for simultaneous improvement of vitamin D status in both mother and child, but its effectiveness is more dependent on the dose and baseline vitamin D status [10,13,21].

When interpreting research results, the influence of environmental and lifestyle factors, such as exposure to solar radiation, diet and geographical latitude, which may modify the body's response to supplementation, should also be taken into account [32].

Available data also indicate a favorable safety profile of vitamin D supplementation, even at higher doses [12,15,30]. Most studies did not report significant adverse effects, suggesting that appropriately monitored supplementation is safe for both mother and child.

The baseline vitamin D status of breastfeeding women is also important and may determine the response to supplementation [25,26,32]. In populations with high rates of deficiency, the effects of supplementation are usually more pronounced.

In conclusion, vitamin D supplementation in breastfeeding women may be an effective strategy for improving vitamin D status in infants. However, its effectiveness depends on the dose, duration of supplementation, and individual and environmental factors [21]. Further research is needed to determine optimal supplementation regimens during lactation [30]. These results have significant implications for public health practice, particularly in the context of strategies for preventing vitamin D deficiency in breastfed infants.

Limitations of the Review

This review has several limitations that should be considered when interpreting the presented results. Primarily, the studies analyzed differed in their vitamin D supplementation regimens. Individual studies used different doses of vitamin D, including both standard preventive doses and high-dose regimens. These differences may hinder direct comparison of results across studies and impact the ability to clearly determine the optimal supplementation dose during lactation.

Another limitation is the varying duration of interventions across the analyzed studies. In some studies, supplementation was administered for several months after delivery, while in others, the follow-up period was shorter. These differences may influence the observed changes in 25-hydroxyvitamin D [25(OH)D] concentrations in both mothers and infants, making direct comparison of results across studies difficult.

Differences in the characteristics of the studied populations should also be noted. The studies analyzed were conducted in different geographic regions, which may influence the baseline vitamin D status of the study

participants. Factors such as sun exposure, diet, and lifestyle may influence vitamin D levels in mothers and their children, and therefore the effects of supplementation.

Another limitation of this review is the relatively small number of randomized controlled trials available assessing the effect of vitamin D supplementation in breastfeeding women on infant vitamin D status. Despite the growing number of publications in this area, there remains a need for larger clinical trials involving more diverse populations.

Despite the above-mentioned limitations, the analyzed studies provide important information on the effect of vitamin D supplementation in breastfeeding women on the vitamin D status of breastfed infants.

Future Research Directions

Despite the growing number of studies on vitamin D supplementation during lactation, many issues remain requiring further clinical research. One of the most important issues is determining the optimal vitamin D dose for breastfeeding women to ensure adequate vitamin D status in infants. Current research indicates that standard supplementation doses may be insufficient to maintain adequate 25-hydroxyvitamin D [25(OH)D] levels in exclusively breastfed infants, but the results regarding the effectiveness of higher doses of supplementation are inconclusive.

Future research should pay particular attention to determining optimal vitamin D supplementation regimens during lactation. Further randomized, controlled trials comparing different doses of vitamin D supplementation in breastfeeding women and assessing their impact on infant 25(OH)D concentrations are needed. These studies should include larger participant populations and longer follow-up periods to allow for more accurate assessment of the long-term effects of supplementation.

An important direction for future research is to assess the impact of vitamin D supplementation during lactation on other aspects of children's health. In addition to its impact on bone metabolism and rickets prevention, the potential impact of vitamin D on immune system development, infection risk, and the development of chronic diseases later in life is increasingly being analyzed.

Additionally, future studies should consider environmental and lifestyle factors that may influence participants' vitamin D status. Factors such as sun exposure, diet, and latitude may play an important role in shaping vitamin D levels in both mothers and their children.

It is also worthwhile to conduct studies comparing the effectiveness of different strategies for preventing vitamin D deficiency in breastfed infants, including direct infant supplementation and vitamin D supplementation in breastfeeding mothers. The results of such studies may contribute to the development of more precise recommendations for vitamin D supplementation during pregnancy and lactation.

In conclusion, further research in this area is necessary to better understand the impact of vitamin D supplementation during lactation on the health of mothers and their infants and to develop optimal strategies to prevent vitamin D deficiency in the breastfed infant population.

Conclusions

The results of this review indicate that vitamin D supplementation in breastfeeding women may be an effective method for improving vitamin D status in breastfed infants. Analysis of available randomized controlled trials suggests that the effectiveness of this strategy is largely dependent on the dose and duration of supplementation. Standard vitamin D doses for breastfeeding women, ranging from 400 to 800 IU per day, do not always ensure adequate 25-hydroxyvitamin D [25(OH)D] levels in exclusively breastfed infants. However, higher doses of supplementation during lactation may lead to more pronounced improvements in vitamin D status in both mothers and their infants.

The results of the analyzed studies also indicate that vitamin D supplementation in breastfeeding women may be a potential alternative to direct supplementation of infants. This strategy allows for simultaneous improvement of vitamin D status in both mother and child and may contribute to increased vitamin D content in breast milk. However, it should be emphasized that the effectiveness of this method may depend on many factors, such as the mother's baseline vitamin D status, diet, lifestyle, and exposure to sunlight.

From a public health perspective, appropriately tailored vitamin D supplementation regimens during lactation may play an important role in preventing vitamin D deficiency in breastfed infants. However, further randomized clinical trials are needed to determine optimal supplementation doses and assess the long-term safety of higher vitamin D doses in breastfeeding women.

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