World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

The role of vitamin d to prevent children's stunting

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World Journal of Advanced Research and Reviews, 2024, 21(03), 341–348

Publication history: Received on 17 January 2024; revised on 28 February 2024; accepted on 01 March 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.21.3.0656

Abstract

Stunting is one of the world's major nutritional problems particularly in developing countries, and is characterized by chronic growth and development impairment in children. According to data from the World Health Organization (WHO), in 2022, the prevalence of stunting was 22.3%, or around 148.1 million. The direct cause of stunting is poor nutritional intake of both macronutrients and micronutrients. One crucial micronutrient for linear growth is vitamin D. Vitamin D deficiency can cause developmental delays in children. Vitamin D supplementation in pregnant women and children may have beneficial effects in preventing stunting and promoting growth in children. The main objective of this study was to determine the role of vitamin D to prevent childrens stunting. This study is a literature review using PubMed and the Google database to identify articles published in the period 2015–2023. In conclusion, vitamin D has an important role to prevent childrens stunting. The effect of vitamin D deficiency on the process of bone growth in stunted toddlers is inhibited by inhibiting the function of IGF-1 in increasing osteoblastogenesis, thereby reducing the rate of bone growth. Stunting can be prevented early on through the adequate intake of macro and micronutrient nutrients. The need for micronutrients is especially important, including vitamin D as an important element in bone metabolism.

Keywords: Vitamin D; Stunting Prevention; Children; Micronutrien; Prenatal

1. Introduction

One serious nutritional issue that still has to be addressed is stunting. In 2022, the World Health Organization (WHO) reported that 22.3% of children, or around 148.1 million, were stunted (1). Stunting is a major nutritional problem that has not been resolved. The incidence of stunting has decreased from the previous year, but it is far from the 2030 Sustainable Development Goals (SGDs) target to end all forms of malnutrition (2). According to data from the Indonesian Nutrition Status Survey in 2022, the stunting rate in Indonesia was 21.7%, a decrease compared to 24.4% in 2021 (3). Stunting is associated with increased morbidity and mortality in young children and poor cognitive performance and psychological functioning in later childhood. It also has adverse long-term health consequences, and in adults, it associated with reduced work capacity, obstetric complications, and an increased risk of overweight and obesity, which may lead to the metabolic syndrome (4,5).

Stunting is identified by assessing a child's height using the height-for-age Z-Score as a general stunting indicator. A child is considered stunted if their height is less than -2 standard deviations from the median of their age and gender-specific standard growth curve (6). Stunting resulting from linear growth failure leads to various pathological conditions associated with increased morbidity, mortality, potential loss of physical growth, impaired neural development, cognitive function, and the development of chronic diseases in adulthood. Poor nutrition increases vulnerability to infections, as malnutrition enhances the risk of infection due to decreased epithelial function and a disrupted immune response (7).

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The direct cause of stunting is poor nutritional intake of both macronutrients and micronutrients. One crucial micronutrient for linear growth is vitamin D. Vitamin D is derived from dietary intake, particularly processed dairy products and fish oil, or synthesized in the skin from ultraviolet light. The body requires vitamin D, or in this case, serum 25-hydroxy vitamin D levels, to stimulate the release of Insulin-Like Growth Factor-1 (IGF-1) in the liver. Insufficient IGF-1 production in children can impact growth due to IGF-1 resistance in the body (8). Vitamin D deficiency can cause developmental delays in children. Vitamin D supplementation in pregnant women and children may have beneficial effects on preventing stunting and promoting growth in children (9). Clinical signs of vitamin D deficiency vary among children, including motor disturbances, abnormal posture, easy falls, shaky hands, dizziness, numbness in fingers, growth retardation, and seizures (10).

2. Material and methods

This research is a literature review. Literature search using PubMed and the Google database, to identify articles published in the period 2011 - 2023. The keywords used to search for this article are Vitamin D, Stunting Prevention, and Children.

3. Results

Tabel 1 Summary of Finding the Role of Vitamin D to Stunting Prevention

No	Author	Research Title	Method	Results
1.	Martha E. van Stuijvenberg *et al.,* (2015) (11)	Low intake of calcium and vitamin D, but not zinc, iron or vitamin A, is associated with stunting in 2- to 5-year-old children	Cross Sectional	Intake of fat, calcium, phosphorous, vitamin D, riboflavin, and vitamin B12 (nutrients that typically occur in milk) was significantly lower in stunted than in non-stunted children (P < 0.05). When excluding children with low birth weight, intake of calcium, vitamin D, and riboflavin were still significantly lower (P < 0.05). Height-for-age z-scores (HAZ) was higher in children who habitually drank milk compared to those who did not (P = 0.003).
2.	Eka Nurhayati *et al.,* (2020) (12)	Dietary diversity, vitamin D intake and childhood stunting	Case Control	Factors which were significantly associated with stunting included young children aged 18-23 months (adjusted OR = 3.84; 95% CI: 1.17-12.26), birth length ≥48 cm (adjusted OR = 0.36; 95% CI: 0.16-0.83), inadequate intake of vitamin D (adjusted OR = 5.18; 95% CI: 1.03-26.02), and diversified diet (adjusted OR = 0.17; 95% CI: 0.03-0.92).
3.	Isnani Nurhayati *et al.,* (2022) (13)	The Effect of Vitamin D Deficiency with Stunting and Overweight	Meta Analysis	Subjects with below-standard vitamin D levels in the body had 1.86 higher risk of experiencing stunting (OR = 1.86; 95% CI 0.90-3.84; p = 0.09). There is a relation between vitamin D deficiency with stunting
4.	Rana R Mokhtar *et al.,* (2018) (14)	Vitamin D status is associated with underweight and stunting in children aged 6-36 months residing in the Ecuadorian Andes	Cross Sectional	Associations between serum 25(OH)D and underweight (defined as weight-for-age Z-score≤-1) and stunting (defined as height-for-age Z-score≤-2) were assessed using multivariate logistic regression. Sensitivity analysis revealed an undernutrition-specific 25(OH)D cut-off of <42·5 nmol/l; 18·6 % of children had serum 25(OH)D<42·5 nmol/l. Low serum 25-hydroxy vitamin D levels are common in children with low weight. It's linked to vitamin D deficiency.
5.	Yaser Sharif *et al.,*	Association of vitamin D, retinol and zinc deficiencies with stunting in toddlers:	Cross Sectional	A significant inverse association was found between serum retinol concentrations and the odds of stunting such that after controlling for potential confounders, toddlers in the highest quartile of serum retinol levels

No	Author	Research Title	Method	Results
	(2020) (15)	findings from a national study in Iran		had 29% lower odds of stunting than those in the lowest quartile (odds ratio [OR]: 0.71, 95% confidence interval [CI]: 0.53–0.97). Furthermore, a significant inverse association was found between serum levels of retinol and stunting in girls (OR: 0.57, 95% CI: 0.34–0.94), urban toddlers (OR: 0.66, 95% CI: 0.44–0.99) and those who did not use nutritional supplements (OR: 0.70, 95% CI: 0.52–0.95). Although serum 25(OH)D3 levels were not significantly associated with stunting in the overall study population. But there's a positive associated between children taking nutritional supplements.
6.	Geeta Trilok Kumar *et al.,* (2011) (16)	Effect of weekly vitamin D supplements on mortality, morbidity, and growth of low birthweight term infants in India up to age 6 months	Randomized Control Trial	Vitamin D supplementation resulted in better vitamin D status as assessed by plasma calcidiol levels at six months. Vitamin D treatment significantly increased standard deviation (z) scores at six months for weight, length, and arm circumference and decreased the proportion of children with stunted growth (length for age z score ≤ 2) or with arm circumference z scores of 2 or less.
7.	Chunhua Song *et al.,* (2021) (17)	Association Between Vitamin D Status and Undernutrition Indices in Children: A Systematic Review and Meta-Analysis of Observational Studies	Systematic Review and Meta Analysis	There is no significant association between vitamin status and risk of stunting. When comparing low and high serum vitamin D concentration categories, there is an inverse link between vitamin D status and wasting, but no relationship with stunting as well as underweight
8.	Nahida Zahir Walli *et al.,* (2017) (18)	Vitamin D Levels in malnourished children under 5 years in a tertiary care center at muhimbili national hospital, Dar es Salaam, Tanzania	Cross Sectional	Vitamin D deficiency was found in 41 of 134 children (30.6%). The mean vitamin D level was 74.8 nmol/l. The mean alkaline phosphatase level was 176.6U/l. Sixty-four (48%) children were found to have severe stunting, of whom 20 (31.2%) were vitamin D deficient. Marasmic children had higher odds of Vitamin D deficiency compared with other forms of malnutrition.
9.	Tiffany Cornelia Angelin *et al.,* (2021) (19)	Growth, dietary intake, and vitamin D receptor (VDR) promoter genotype in Indonesian school-age children	Cross Sectional	The result showed a significant correlation between energy and protein intake with height-for-age z-score (HAZ) of the children ($p = 0.030$ and $p = 0.016$, respectively). The association between VDR gene and HAZ was not found ($p > 0.05$). Adjusted by other factors, protein intake was significantly correlated with HAZ ($\beta = 0.034$, 95% CI 0.015–0.052, $p < 0.001$, adj. $R2 = 0.089$). The children in our study had a favorable Vitamin D Receptor (VDR) gene genotype, however the effect of VDR gene promoter activity might not be revealed due to very low vitamin D and calcium intake to stimulate intestinal calcium absorption which in turn affects HAZ.
10.	Eunice N Toko *et al.,* (2016) (20)	Maternal vitamin D status and adverse birth outcomes in children from Rural Western Kenya	Prospective Cohort Study	Deficient plasma 25(OH)D levels were associated with a four-fold higher risk of stunting in neonates ($p = 0.04$). These findings add to the existing literature about vitamin D and its association with linear growth.
11.	Martha E. van	Low Intake of Calcium and Vitamin D is	Retrospective Study	There was a significant difference in intake of fat, calcium, phosphorous, vitamin D, riboflavin and

No	Author	Research Title	Method	Results
	Stuijvenberg *et al.*, (2015) (21)	Associated with Stunting in 2-5-Year-Old Children from an Impoverished South African Community		vitamin B12 between children who were stunted and those not stunted. Low intake of calcium and vitamin D, presumably due to inadequate milk intake after weaning, seems to significantly contribute to the high levels of stunting in this community
12.	Miliku *et al.*, (2016) (22)	Maternal vitamin D concentrations during pregnancy, fetal growth patterns, and risks of adverse birth outcomes	Prospective Cohort	Compared with mothers with second-trimester 25(OH) D concentrations in the highest quartile, those with 25(OH) D concentrations in the lower quartiles had offspring with third-trimester fetal growth restriction, leading to a smaller head circumference, shorter body length, and lower body weight at birth.
13.	Perez Lopez *et al.*, (2015) (23)	Effect of vitamin D supplementation during pregnancy on maternal and neonatal outcomes	Systematic Review and Meta Analysis	Birth weight and birth length were significantly greater for neonates in the vitamin D group; mean difference: 107.6 g (95% CI 59.9-155.3 g) and 0.3 cm (95% CI 0.10-0.41 cm), respectively. Vitamin D supplementation during pregnancy was associated with increased circulating 25(OH)D levels, birth weight, and birth length.
14.	Soudabe Motamed *et al.*, (2019) (24)	Efficacy of two different doses of oral vitamin D supplementation on inflammatory biomarkers and maternal and neonatal outcomes	True Experiment Randomized Clinical Trial	Circulating concentrations of 25(OH)D increased in both intervention groups with more increment in 2,000 IU/d than in 1,000 IU/d (46.7 ± 30.7 vs. 24.0 ± 21.07 nmol L−1, P=.001). Vitamin D3 supplementation at 2000 IU/day has increased neonatal weight, length, and head circumference.
15.	Pegah Nasiri Babadi *et al.*, (2021) (25)	The association of serum levels of zinc and vitamin D with wasting among Iranian pre-school children	Cross Sectional	The prevalence of vitamin D and zinc deficiencies was 18.8% and 12.7%. The prevalence of vitamin D and zinc deficiencies among Iranian pre-school children aged 6 years was 18.8 and 12.7%, respectively. Serum levels of vitamin D and zinc were inversely associated with wasting either before or after controlling for confounders.
16.	Ranadip Chowdury *et al.*, (2020) (26)	Vitamin D status in early childhood is not associated with cognitive development and linear growth at 6-9 years of age in North Indian children	Cohort	Vitamin D status was not associated with any of the cognitive outcomes or linear growth [Adjusted β coefficient for height for age z-score between deficient and sufficient children was - 0.06 (95% CI - 0.24 to 0.11)] at follow up.
17.	Daniel E Roth *et al.*, (2019) (27)	Vitamin D Supplementation in Pregnancy, Lactation, and Infant Growth	Randomized Controlled Trial	Prenatal maternal vitamin D supplementation had no significant effect on infant length or other anthropometric outcomes by year 1 of age, no significant effects of any vitamin D dose on preterm birth, low birth weight, or small for gestational age.
18.	Brodget E Young *et al.*, (2012) (28)	Maternal vitamin D status and calcium intake interact to affect fetal skeletal growth in utero in pregnant adolescents	Prospective Cohort	Maternal 25(OH) D>50 nmol/L was significantly positively associated with fetal femur and humerus Z scores. Maternal vitamin D status are both needed to maximize fetal bone growth.

4. Discussion

4.1. Stunting and Vitamin D

During the critical period or the first 1000 days of life (from child conception to the age of 2 years), vitamin D deficiency can increase the risk of growth delay. Vitamin D levels are influential and have a significant relationship with linear growth and are important for normal growth in children (29). Vitamin D deficiency was correlated with a decrease in linear growth and stunting (30). A study conducted by Stuijvenberg et al. (2015) showed that stunting in children aged 2-5 in South Africa occurred in children who consumed less vitamin D, calcium, riboflavin, and fat than normal children (11).

Nutritional deficiencies, including vitamin D deficiency, have the highest prevalence in children. In a study by Mogire et al. (2021) of 4509 children living in Africa, the median value of 25-hydroxy vitamin D concentration was 77 nmol/L which means that the child is in the category of vitamin D insufficiency. Vitamin D deficiency is when the serum level of 25-hydroxy Vitamin D serum is less than 20 ng/mL or 50 nmol/L. Vitamin D insufficiency is a serum value of serum levels of 25 hydroxy vitamin D 20-30 ng/ml or 50-75 nmol / L, when serum 25OHD levels are ≥ 100 or ≥ 250, they are classified as having a risk of toxicity (31). The clinical signs of vitamin D deficiency that each child experiences are different. The first is motor disorders like stiffness, abnormal posture, easy falling, and shaking hands. There were also neurological disorders such as dizziness, fingers, growth retardation, and seizures (10).

Vitamin D deficiency in child neurobehavioural from a systematic review conducted by Mutua et al (2020) that vitamin D affects child cognitive development. Children who have high serum 25-hydroxy vitamin D levels have high IQ scores. High serum 25-hydroxy vitamin D levels in children aged 18-30 months in the United Kingdom improve good motor development. Infants born to mothers with serum 25-hydroxy vitamin D levels of less than 37.5 nmol/L had a poor speech ability score compared to those born to a mother with a serum 25 hydroxy Vitamin D level of ≥75 nmol/L (32). Vitamin D plays a role in the child's linear growth that causes mineralization and maintenance of bones in skeletal health (30). This is related to a study by Kumar et al. (2011) that intervened in the administration of 35 μg of vitamin D supplements to babies aged 7 days with BBLR up to 6 months and obtained a significant increase in the standard deviation score (z) for weight, length and decrease in the proportion of children with impaired growth (16).

Vitamin D deficiency can lead to delayed growth of the inflorescences in a child. Vitamin D supplementation in pregnant women and children may have beneficial effects in preventing stunting and boosting growth on children (9). It is also consistent with Zakharova (2019) explaining the relationship between vitamin D deficiency and growth disorders, including stunting, and emphasizing the importance of vitamin D status for linear growth and growth as well as immunity in children and adolescents (33). Vitamin D supplementation for stunting children plays a role in the musculoskeletal system and the impact of vitamin D deficiency on child development. Due to vitamin D's central role in the musculoskeletal system and consequently the strong negative impact on bone health in cases of vitamin D deficiency (34). Although not specifically discussing interventions against stunting, based on the study Chairunnisa et al,(2018) analyzed the difference in vitamin D, calcium, and phosphorus intake in children aged 12 to 24 months who have or do not have growth retardation, thus proving the importance of vitamin D supplementation in children suffering from stunting. Therefore, various sources emphasize the significance of the intervention of Vitamin D in children with developmental delays to prevent and correct growth problems (35).

The results of this study are also related to the Indonesian government's measures in providing stunting reduction interventions in two forms of specific nutritional interventions and nutrition-sensitive interventions. Specific nutritional interventions contributed 30% to a decrease in stunting involving the health sector through the first 1,000 days of life movement starting from the mother's pregnancy to childbirth (36). Based on a study by Sukmawati, et al. (2023) it was found the vitamin D supplementation to pregnant mothers had an impact on many aspects of anthropometry, including the length of the newborn's. The subjects suggested that vitamin D supplementation interventions ranging between 1400–60,000 per week in prenatals had an impact on stunting prevention (9).

Micronutrients such as zinc, vitamin A, and vitamin D are known to be involved in growth hormone and insulin-like growth factor (IGF), GH and IGF1 are capable of stimulating tissues, and GH is also capable of processing differentiation and proliferation of prechondrocytes and osteoblasts. Deficiency of such micronutrients can affect DNA and RNA in mensythesis for the replication and differentiation of chondrocyts and osteoblasts involved in chondrogenesis and bone formation. The secretion of GH and the suppression of IGF1 in the liver and bone caused the occurrence of stunting. Vitamin D which functions in calcium and phosphorus metabolism can be obtained from daily intake and sun exposure. Regulation in metabolism includes bone growth and mineralization. Vitamin D deficiency can cause delayed mineralization during childhood (37).

Vitamin D is produced by the skin through exposure to ultraviolet rays, undergoing hydroxylation in the liver and kidneys into active vitamin D. Vitamin D has a function to regulate the levels of calcium and phosphorus in the blood along with the thyroid glands to help the absorption of Calcium and Phosphorus from the intestines and affect the work of the endocrine glands. The low intake of vitamin D in young people due to the variation of sources of Vitamin D intake from food is still very limited. The dietary sources of vitamin D are very rare, only obtained from processed foods such as milk, fish fat and fish oil in the form of vitamin D3. The low intake of vitamin D in the youth because it is difficult to meet the daily requirement for vitamin D. So, vitamin D intervention in stunting youth needs to be given to adequate vitamin D needs to improve the status of the stunt (38).

5. Conclusion

The results of this study show that there is an effect of vitamin D deficiency on the process of bone growth in stunted toddlers by inhibiting the function of IGF-1 in increasing osteoblastogenesis, thereby reducing the rate of bone growth. Stunting can be prevented early on through the adequate intake of macro and micronutrient nutrients. The need for micronutrients is especially important, including vitamin D as an important element in bone metabolism. In conclusion, Vitamin D may thus be an important modifiable nutritional factor to prevent stunting.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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