CRITICAL EVALUATION OF THE RELATIONSHIP BETWEEN VITAMIN D INTAKE, LINEAR GROWTH IMPAIRMENT, AND THE RISK OF STUNTING IN CHILDREN

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ABSTRAK
Stunting adalah gangguan gizi kronis yang menghambat pertumbuhan linear anak-anak dan tetap menjadi masalah kesehatan global dan nasional yang serius. Kekurangan vitamin D dapat mengganggu fungsi plat pertumbuhan dan meningkatkan risiko stunting. Tujuan studi ini adalah untuk mengevaluasi secara kritis hubungan antara asupan vitamin D, pertumbuhan linear, dan risiko stunting pada anak-anak, berdasarkan bukti dari uji klinis terkontrol acak (RCT). Ulasan sistematis literatur dilakukan menggunakan basis data PubMed dan ScienceDirect. Kriteria pencarian meliputi publikasi dalam lima tahun terakhir (2021–2025), ketersediaan teks lengkap, bahasa Inggris, dan desain RCT. Istilah pencarian Boolean diterapkan: “Vitamin D” ATAU “1,25(OH)$_2$D$_3$” ATAU “Calcitriol” ATAU “Calciferol” DAN “tinggi badan” ATAU “pertumbuhan anak” ATAU “stunting” DAN “anak” ATAU “anak-anak” ATAU “masa kanak-kanak.” Dari 1.787 artikel yang diidentifikasi, enam RCT dianalisis secara kritis. Pada keenam RCT tersebut, suplementasi vitamin D dengan dosis berkisar antara 400 IU/hari hingga dosis bolus 400.000 IU secara signifikan meningkatkan kadar serum 25(OH)D ($p < 0,05$) dan memperbaiki hasil pertumbuhan linear. Susu yang diperkaya, suplementasi dosis tinggi secara berkala, dan konsumsi oral harian terbukti dapat meningkatkan parameter antropometrik dan densitas mineral tulang. Efek sinergis diamati ketika vitamin D dikombinasikan dengan asupan kalsium yang cukup. Kesimpulan studi ini adalah bahwa defisiensi vitamin D berkontribusi pada gangguan pertumbuhan linear dan peningkatan risiko stunting melalui gangguan regulasi kalsium-fosfat, peningkatan hormon paratiroid, penurunan mineralisasi tulang, dan penurunan IGF-1.

Kata kunci **:** anak, anak-anak, kalsiferol, kalsitriol, masa kanak-kanak, stunting, tinggi badan, vitamin D, 1,25(OH)$_2$D$_3$

ABSTRACT
Stunting is a chronic nutritional disorder that hinders children’s linear growth and remains a major global and national health problem. Vitamin D deficiency may impair growth plate function and increase the risk of stunting. The objective of this study is to critically evaluate the association between vitamin D intake, linear growth, and stunting risk in children, based on evidence from randomized controlled trials (RCTs). A systematic literature review was conducted using PubMed and ScienceDirect databases. Search criteria included publications from the last five years (2021–2025), full-text availability, English language, and RCT design. Boolean search terms were applied: “Vitamin D” OR “1,25(OH)$_2$D$_3$” OR “Calcitriol” OR “Calciferol” AND “height” OR “child growth” OR “stunting” AND “child” OR “children” OR “childhood.” From 1,787 identified articles, six RCTs were critically analyzed. Across these six RCTs, vitamin D supplementation ranging from 400 IU/day to a 400,000 IU bolus significantly increased serum 25(OH)D levels ($p < 0.05$) and improved linear growth outcomes. Synergistic effects were observed when vitamin D was combined with adequate calcium intake. The conclusion of this study is that vitamin D deficiency contributes to impaired linear growth and increased stunting risk through calcium-phosphate dysregulation, elevated parathyroid hormone, reduced bone mineralization, and decreased IGF-1.

Keywords **:** *children, children, calcifediol, calcitriol, childhood, stunting, height, vitamin D, 1,25(OH)$_2$D$_3$*

INTRODUCTION

Stunting is a condition of impaired growth in children resulting from chronic malnutrition, particularly within the first 1,000 days of life, starting from pregnancy through the first two years of age (De Simone et al., 2025). Stunted children have a height-for-age below the standard. According to the WHO growth chart, a child is considered stunted if their height-for-age is below -2 standard deviations (SD) from the median growth curve for age(Rudatiningtyas et al., 2024) This condition arises from prolonged nutritional deficiency, recurrent infections, and adverse socioeconomic factors (Theurich et al., 2022). Global data in 2024 reported that 150.2 million children under five years of age were stunted, representing 23.3% of this population worldwide. Regional distribution shows Asia contributing approximately 51%, Africa 43%, Latin America and the Caribbean 2%, with the remainder in Europe and Oceania (De Simone et al., 2025). In Indonesia, the prevalence of stunting based on the 2024 Indonesia Nutrition Status Survey (SSGI) was 19.8%(Rudatiningtyas et al., 2024). The persistently high prevalence highlights the need for specific interventions beyond macronutrient supplementation, including consideration of micronutrients that may play a therapeutic role, one of which is vitamin (O'Mahony et al., 2011).

Vitamin D is an essential nutrient involved in multiple physiological functions. Its active form, 1,25-dihydroxyvitamin D_3 (calcitriol), is a hormone that plays a vital role in bone growth. The primary function of vitamin D is to enhance intestinal absorption of calcium and phosphorus, which are critical for bone mineralization and skeletal development in children (Wang et al., 2012). Additionally, vitamin D modulates immune function, reduces the risk of infections and inflammation, facilitates cellular differentiation, and maintains hormonal balance, including the regulation of growth-related hormones such as insulin-like growth factor 1 (IGF-1) (Mohd Ghozali et al., 2022). Deficiency of vitamin D can impair the growth plate, which is crucial for longitudinal bone development during childhood, thereby hindering linear growth and increasing the risk of stunting (Trummer et al., 2017). Several studies have highlighted that inadequate vitamin D levels in early life are strongly associated with impaired growth trajectories and higher susceptibility to stunting. Adequate vitamin D status during childhood is therefore considered not only a determinant of bone health but also an important factor in achieving optimal growth and preventing long-term developmental consequences (Stounbjerg et al., 2021).

Based on this background, the present literature review was conducted to critically evaluate the association between vitamin D intake, impaired linear growth, and stunting risk in children. The objective of this study is to critically evaluate the relationship between vitamin D intake, linear growth, and the risk of stunting in children, based on evidence from randomised controlled trials (RCTs).

METHODS

This study is a systematic literature review focusing on articles with a *Randomized Controlled Trial (RCT)* design. Data were collected from two international databases, PubMed and ScienceDirect, with publication years limited to the period 2021–2025. The search strategy employed Boolean operators with specific keywords, including "Vitamin D," "1,25(OH)$_2$D$_3$," "Calcitriol," "Calciferol," "Height," "Child growth," "Stunting," "Child," "Children," and "Childhood." Data analysis was carried out through a screening process based on predefined inclusion and exclusion criteria, followed by an eligibility assessment that resulted in six RCTs meeting the requirements for review. Since this study relied solely on secondary data from previously published literature and did not involve direct human subjects, ethical approval was not required.

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RESULT

The literature search across PubMed and ScienceDirect, yielded a total of 1.787 articles. After applying the inclusion and exclusion criteria, six randomized controlled trials (RCTs) were eligible and included for review.

Table 1. Summarizes The Key Characteristics and Findings Of The Included Studies, Covering Study Design, Population, Intervention, Outcomes and Main Conclusions Relevant To The Association Between Vitamin D and Growth in Children

Author/ Year/ Country	Study Design	Population / Sample Size	Baseline Vitamin D Level (mean ng/mL)	Intervention (Dose, Duration, Route)	Measurement Methods	Main Findings	Conclusion
Javeria Saleem et al., 2025, Pakistan (10)	RCT, double blind, multicenter (2 hospitals)	259 children aged 6–59 months with severe acute malnutrition (112 boys and 147 girls).	21,8 ng/mL	400,000 IU administered in two doses: the first dose of 200,000 IU orally at hospital discharge, and the second dose of 200,000 IU orally, given 14 days later.	Serum 25(OH)D; anthropometry (WHZ); MDAT; lean mass index; follow-up at 2 and 6 months.	Vitamin D_3 supplementation significantly increased serum 25(OH)D levels (+100 nmol/L:p < 0.001) and had a positive impact on the nutritional status of children, playing an important role in supporting linear growth and nutritional recovery in children with severe malnutrition.	High-dose vitamin D_3 supplementation in children with severe acute malnutrition was effective in increasing vitamin D levels. These findings support the notion that vitamin D may contribute to the improvement of stunting and linear growth when accompanied by adequate macro- and micronutrient interventions.
Davaasambuu Ganmaa et al., 2023, Mongolia (14)	RCT, double-blind, multicenter (18 schools)	8,851 healthy children aged 6–13 years (4,489 boys and 4,362 girls)	10–12 ng/mL	Vitamin D_3 14,000 IU/week orally for 3 year.	Serum 25(OH)D; height (HAZ); BMI z-score; body composition; Tanner stage.	Vitamin D_3 supplementation at 14,000 IU/week for 3 years significantly increased serum 25(OH)D levels in school-aged children living in regions with a high	Vitamin D supports linear growth and has the potential to prevent stunting in children with deficiency.

						prevalence of deficiency (MD = +20.3 ng/mL; 95% CI: 19.9–20.6; $p < 0.001$). This improvement in vitamin D status suggests a potential contribution to linear growth, particularly in children with low baseline vitamin D levels.	
Wei-Qin Tang et al., 2023, China (18)	RCT double-blind	196 preterm infants aged 28–32 weeks GA (Gestational Age) (99 boys and 97 girls).	Not reported; post-intervention level at 36 weeks PMA (Postmenstrual Age): Nesting + vitamin D: 38.4 ng/mL vs. Nesting: 15.9 ng/mL.	Vitamin D_3 400 IU/day orally, continued until 36 weeks PMA (approximately 8 weeks)	Serum 25(OH) D; anthropometry (weight, length, BMI, head circumference); Premie-Neuro (PN) scoring.	Vitamin D_3 supplementation at 400 IU/day orally in preterm infants up to 36 weeks PMA significantly increased serum 25(OH)D levels ($p < 0.001$) and supported improvements in body weight, length ($p < 0.05$), head circumference, and neurological scores compared with the control group.	Vitamin D supplementation in preterm infants significantly supported linear growth and neurological development. These findings reinforce the potential of vitamin D as an early intervention contributing to stunting prevention, particularly in high-risk populations such as preterm infants.
Raman Kumar Marwaha, et al., 2021, India (13)	RCT double-blind.	200 healthy children aged 5–10 years (99 boys and 101 girls).	14,4 ng/mL	milk fortified with vitamin D_2 at a dose of 240 IU per day, administered daily for 3 months.	Serum 25(OH) D (measured using ELISA or LC-MS/MS, not	Serum 25(OH)D levels increased to 24.1 ng/mL, with a reduction in deficiency prevalence from 78% to 29%. A	Vitamin D_2 fortification increased vitamin D levels and supported linear growth, indicating its potential role in the

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					specified).	significant increase in height was observed in the intervention group compared with the control group ($p < 0.001$).	prevention and management of stunting.
Francesca L Crowe et al., 2021, Afghanistan (15)	RCT double-blind.	3,046 stunted children aged 1–11 months (1,591 boys and 1,455 girls).	15 ng/mL	High-dose vitamin D_3, 100,000 IU orally every 3 months for 18 months.	Serum 25(OH) D; length-for-age z-score (LAZ); bone radiography.	Periodic high-dose vitamin D supplementation over 18 months significantly increased height in stunted children, particularly when combined with a calcium intake of ≥300 mg/day ($p = 0.05$).	Vitamin D is effective in promoting linear growth in stunted children when combined with adequate calcium intake, highlighting the importance of nutritional synergy in growth interventions.
Nanna G Stounbjerg et al., 2021, Denmark (11)	RCT double-blind.	200 healthy children aged 6–8 years (102 boys and 98 girls).	32,3 ng/mL	Vitamin D_3 20 µg/day (800 IU/day) orally and/or high-protein yogurt (260 g/day), administered for 24 weeks.	Serum 25(OH) D; DXA (BMD, BMC, BA); height-for-age z-score (LAZ).	Daily supplementation with vitamin D_3 at 800 IU for 24 weeks increased spinal bone mineral density, a key component in supporting linear growth in children ($p = 0.041$).	Vitamin D supports bone mineralization and linear growth, and may potentially aid in catch-up growth in stunted children with low vitamin D levels.

This table summarizes six randomized controlled trials (RCTs) conducted in different countries investigating the role of vitamin D supplementation in child growth. Overall, the studies consistently demonstrated that vitamin D administration whether as high single doses, daily supplementation, food fortification, or in combination with other nutrients significantly increased serum 25(OH)D levels in children. Improved vitamin D status was associated with positive outcomes, including enhanced linear growth, better nutritional recovery, improved bone mineralization, and even neurological development in preterm infants. Several trials further emphasized the importance of combining vitamin D with other nutrients, such as calcium and protein, to maximize its growth-promoting effects. Collectively, these findings

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strengthen the evidence that vitamin D can serve as a potential intervention in preventing and addressing childhood stunting.

DISCUSSION

Vitamin D has a central role in bone growth and height development in children through various physiological mechanisms. Its active form, 1,25-dihydroxyvitamin D (calcitriol), is essential for regulating calcium and phosphate metabolism, which provide a fundamental basis for bone formation and mineralization. Moreover, vitamin D modulates growth hormone (GH) pathways, including upregulation of GH expression and synthesis of insulin-like growth factor 1 (IGF-1), key mediators of linear growth (O'Mahony et al., 2011; Wang et al., 2012) Vitamin D deficiency leads to metabolic and hormonal disturbances that may progressively result in growth retardation or stunting. The underlying pathophysiological mechanisms are as follows:

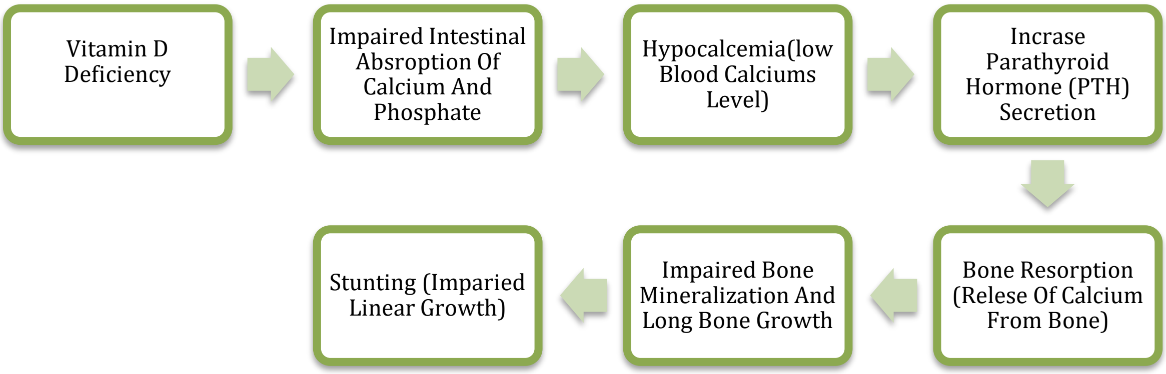

Figure 1. Pathophysiology of Stunting Due to Vitamin D Deficiency

Vitamin D deficiency represents the initiating factor in impaired linear growth. Vitamin D is required for intestinal absorption of calcium and phosphate, as well as for stimulation of IGF-1 synthesis. Despite children living in regions with high sunlight exposure, the prevalence of stunting remains high (21.8%), indicating that other factors such as disturbances in vitamin D metabolism or mutations in the vitamin D receptor (VDR), which may occur due to high UV exposure also affect the efficacy of vitamin D (Angelin et al., 2021). Vitamin D also plays a role in stimulating the expression of calcium transport proteins in the intestinal mucosa. In its absence, calcium and phosphate absorption is impaired. A study in children with celiac disease demonstrated that reduced vitamin D levels were accompanied by stunting in up to 31% of cases, caused by malabsorption of essential nutrients including vitamin D and minerals (Almahmoud et al., 2024). This reinforces evidence that impaired intestinal absorption can directly impact vitamin D status and child growth.

Low calcium absorption results in hypocalcemia and a compensatory increase in parathyroid hormone (PTH) secretion. However, elevated PTH also induces calcium resorption from bone, which over time reduces bone density and integrity. Studies have shown that high-dose vitamin D administration improves serum 25(OH)D levels and nutritional status in children with severe acute malnutrition, supporting the role of vitamin D in maintaining calcium homeostasis (O'Donovan et al., 2025; Wu et al., 2023). Moreover, maternal vitamin D supplementation during pregnancy has been reported to positively affect various neonatal anthropometric parameters, including birth length, emphasizing that optimal vitamin D status from gestation plays a critical role in supporting linear growth in children (Sukmawati et al., 2023).

Adequate calcium and phosphate intake is crucial for bone mineralization, particularly in long bones, which determine stature. Fortification of milk with vitamin D_2 has been shown to

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effectively increase serum 25(OH)D levels and height in healthy children, further confirming the role of vitamin D in promoting linear growth (Marwaha et al., 2021). Overall, the cascade of disturbances resulting from vitamin D deficiency—from impaired mineral absorption, hypocalcemia, bone resorption, to hormonal dysregulation—ultimately leads to stunting, defined as failure to reach optimal linear growth potential. Long-term supplementation with vitamin D_3 has been shown to significantly increase serum 25(OH)D levels, improve linear growth, and reduce the risk of stunting in children with vitamin D deficiency (Ganmaa et al., 2023).

CONCLUSION

Vitamin D deficiency contributes to impaired linear growth and an increased risk of stunting through disturbances in calcium-phosphate metabolism, elevated parathyroid hormone (PTH), reduced bone mineralization, and decreased IGF-1 levels. Vitamin D supplementation has been proven to improve nutritional status, enhance linear growth, and may prevent stunting in children.

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REFERENCES

Almahmoud, E., Alkazemi, D. U. Z., & Al-Qabandi, W. (2024). *Growth Stunting And Nutritional Deficiencies Among Children And Adolescents With Celiac Disease In Kuwait: A Case–Control Study*. *Children*, *11*(9), 1042. Https://Doi.Org/10.3390/Children11091042

Angelin, T. C., Bardosono, S., Shinta, D., & Fahmida, U. (2021). *Growth, Dietary Intake, And Vitamin D Receptor (VDR) Promoter Genotype In Indonesian School-Age Children*. *Nutrients*, *13*(9), 2904. Https://Doi.Org/10.3390/Nu13092904

De Simone, M. S., Zabberoni, S., Costa, A., Tenaglia, E., & Tieri, G. (2025). *The Effects Of An Immersive Virtual Reality And Telemedicine-Based Multi-Component Intervention In Individuals With Subjective Cognitive Decline: Study Protocol Of A Randomized Controlled Trial*. *Frontiers In Psychology*, *16*. Https://Doi.Org/10.3389/Fpsyg.2025.1591239

Ganmaa, D., Bromage, S., Khudyakov, P., Erdenenbaatar, S., Delgererekh, B., & Martineau, A. R. (2023). *Influence Of Vitamin D Supplementation On Growth, Body Composition, And Pubertal Development Among School-Aged Children In An Area With A High Prevalence Of Vitamin D Deficiency*. *JAMA Pediatrics*, *177*(1), 32. Https://Doi.Org/10.1001/Jamapediatrics.2022.4581

Marwaha, R. K., Dabas, A., Puri, S., Kalaivani, M., Dabas, V., Yadav, S., Dang, A., Pullakhandam, R., Gupta, S., & Narang, A. (2021). *Efficacy Of Daily Supplementation Of Milk Fortified With Vitamin D2 For Three Months In Healthy School Children: A Randomized Placebo Controlled Trial*. *Indian Pediatrics*, *58*(9), 820–825. Https://Doi.Org/10.1007/S13312-021-2300-9

Mohd Ghozali, N., Giribabu, N., & Salleh, N. (2022). *Mechanisms Linking Vitamin D Deficiency To Impaired Metabolism: An Overview*. *International Journal Of Endocrinology*, *2022*, 1–16. Https://Doi.Org/10.1155/2022/6453882

O'Donovan, G., Allen, D., Nkosi-Gondwe, T., Anujuo, K., Abera, M., Kirolos, A., Olga, L., Thompson, D., Mckenzie, K., Wimborne, E., Cole, T. J., Koulman, A., Lelijveld, N., Crampin, A. C., O'Donovan, G., Allen, D., Nkosi-Gondwe, T., Anujuo, K., Abera, M., … Kerac, M. (2025). *Weight Gain Among Children Under Five With Severe Malnutrition In Therapeutic Feeding Programmes: A Systematic Review And Meta-Analysis*. *Eclinicalmedicine*, *81*, 103083. Https://Doi.Org/10.1016/J.Eclinm.2025.103083

O'Mahony, L., Stepien, M., Gibney, M. J., Nugent, A. P., & Brennan, L. (2011). *The Potential Role Of Vitamin D Enhanced Foods In Improving Vitamin D Status. Nutrients*, *3*(12), 1023–1041. Https://Doi.Org/10.3390/Nu3121023

Rudatiningtyas, F. U., Khotimah, K., & Satwanto, B. G. (2024). Hubungan Antara Berat Badan Lahir Dengan Status Gizi Pada Balita Di Puskesmas I Kembaran Tahun 2023.

Stounbjerg, N. G., Thams, L., Hansen, M., Larnkjær, A., Clerico, J. W., Cashman, K. D., Mølgaard, C., & Damsgaard, C. T. (2021). *Effects Of Vitamin D And High Dairy Protein Intake On Bone Mineralization And Linear Growth In 6- To 8-Year-Old Children: The D-Pro Randomized Trial. The American Journal Of Clinical Nutrition*, *114*(6), 1971–1985. Https://Doi.Org/10.1093/Ajcn/Nqab286

Sukmawati, S., Hermayanti, Y., Fadlyana, E., Mulyana, A. M., Nurhakim, F., & Mediani, H. S. (2023). *Supplementation Of Prenatal Vitamin D To Prevent Children's Stunting: A Literature Review*. *International Journal Of Women's Health*, *Volume 15*, 1637–1650. Https://Doi.Org/10.2147/IJWH.S431616

Theurich, M. A., Fewtrell, M., Baumgartner, J., Perkin, M. R., Breda, J., Wickramansinghe, K., Weber, M. W., & Koletzko, B. (2022). *Moving Complementary Feeding Forward*. *Journal Of Pediatric Gastroenterology And Nutrition*, *75*(4), 411–417. Https://Doi.Org/10.1097/MPG.0000000000003562

Trummer, C., Schwetz, V., Pandis, M., Grübler, M., Verheyen, N., Gaksch, M., Zittermann, A., März, W., Aberer, F., Lang, A., Friedl, C., Tomaschitz, A., Obermayer-Pietsch, B., Pieber, T., Pilz, S., & Treiber, G. (2017). *Effects Of Vitamin D Supplementation On IGF-1 And Calcitriol: A Randomized-Controlled Trial*. *Nutrients*, *9*(6), 623. Https://Doi.Org/10.3390/Nu9060623

Wang, Y., Zhu, J., & Deluca, H. F. (2012). *Where Is The Vitamin D Receptor? Archives Of Biochemistry And Biophysics*, *523*(1), 123–133. Https://Doi.Org/10.1016/J.Abb.2012.04.001

Wu, F., Fuleihan, G. E.-H., Cai, G., Lamberg-Allardt, C., Viljakainen, H. T., Rahme, M., Grønborg, I. M., Andersen, R., Khadilkar, A., Mughal, M. Z., Mølgaard, C., Larnkjær, A., Zhu, K., Riley, R. D., & Winzenberg, T. (2023). *Vitamin D Supplementation For Improving Bone Density In Vitamin D–Deficient Children And Adolescents: Systematic Review And Individual Participant Data Meta-Analysis Of Randomized Controlled Trials*. *The American Journal Of Clinical Nutrition*, *118*(3), 498–506. Https://Doi.Org/10.1016/J.Ajcnut.2023.05.028