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Review Article

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The Therapeutic Effects of Multivitamins on Growth in Normal and Malnourished Children: A Systematic Review

Ashraf Soliman[1*], Sohair ElSiddig[1], Fawzia Alyafei[1], Nada Alaaraj[1], Noor Hamed[1], Shayma Ahmed[1], Noora AlHumaidi[1], Ahmed Khalil[2], Ahmed Elawwa[1] and Nada Soliman[3]

[1]*Department of Pediatrics, Hamad General Hospital, Doha, Qatar*
[2]*Department of Pharmacy, Hamad General Hospital, Doha, Qatar*
[3]*Department of Public Health, North Dakota State University, USA*

[*]**Corresponding author**
Ashraf Soliman, Department of Pediatrics, Hamad General Hospital, Doha, Qatar.

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ABSTRACT

Background: Micronutrient deficiencies play a significant role in impaired growth among children, particularly in malnourished populations. Vitamins are essential cofactors in metabolic pathways that regulate bone growth, weight gain, and endocrine function, particularly through insulin-like growth factor-1 (IGF-1), a crucial mediator of somatic growth. The impact of multivitamin supplementation on height standard deviation scores (SDS), weight gain, and IGF-1 levels have been widely debated, yielding mixed evidence regarding its efficacy in healthy and malnourished children. This systematic review evaluates the therapeutic role of multivitamin in pediatric growth, highlighting differences in responses based on nutritional status and vitamins composition.

Objective: This review aims to:

1. Assess the effectiveness of multivitamin supplementation in improving height SDS, weight gain, and IGF-1 levels in both normal and malnourished children.
2. Identify key micronutrients contributing to growth enhancement.
3. Compare findings across different studies to determine optimal supplementation strategies and address gaps in research methodologies.

Methods: A systematic review of studies published between 2000 and 2025 was conducted, focusing on randomized controlled trials, cohort studies, and meta-analyses that assessed the effects of multivitamin supplementation on pediatric growth. A total of 116 studies were screened, with 45 meeting the inclusion criteria. Data on height SDS, weight gain, and IGF-1 responses were extracted, analyzed, and compared across studies.

Results: Multivitamin supplementation significantly improved growth velocity and weight gain in malnourished children, particularly those with deficiencies in vitamins A, D, B-complex, and zinc. IGF-1 level was notably increased with vitamin D and B-complex supplementation, supporting their role in endocrine-mediated growth stimulation. In normal children, multivitamin effects were less pronounced; nevertheless, they still showed positive trends in height SDS and IGF-1 responses. Variability in study design, sample size, and nutrient formulations influenced the observed outcomes.

Conclusion: Multivitamin supplementation improves growth outcomes in malnourished children and may have mild to moderate effects in normal children. Future research should focus on standardized supplementation protocols, long-term follow-up, and mechanistic studies to refine intervention strategies and optimize pediatric growth outcomes.

Keywords: Multivitamins, Child growth, Malnutrition, IGF-1, Weight Gain, Linear Growth, Supplementation, Micronutrient Deficiency

Introduction

Childhood growth is influenced by a combination of genetic, environmental, and nutritional factors, with micronutrient intake playing a crucial role in determining height and weight gain

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[1]. Micronutrient deficiencies, particularly of vitamins A, D, B-complex, and zinc, are associated with growth retardation, stunting, and developmental delay in children [2,3]. Multivitamin supplementation has been proposed as an effective intervention to address these deficiencies and improve linear growth and overall health outcomes [4].

Despite extensive research, the impact of multivitamin on growth remains a subject of debate. Some studies suggest that multivitamin supplementation contributes to significant improvements in weight and height gain, particularly in malnourished populations [5,6]. However, others report minimal or inconsistent effects, with growth benefits often dependent on baseline nutrient deficiencies and concurrent dietary interventions [7]. For instance, Locks et al. found no significant reduction in stunting among Tanzanian children receiving multivitamin [8]. In contrast, Taneja et al. observed improved height-for-age z-scores when supplementation was combined with zinc [9].

The physiological mechanisms by which vitamins influence growth involve their role in metabolic pathways, immune function, and bone mineralization. Vitamin A is essential for immune competence and cellular growth, with deficiencies leading to growth impairment and increased morbidity [10]. Vitamin D plays a vital role in calcium homeostasis and bone formation, and its deficiency has been linked to rickets and compromised growth outcomes [11]. B-complex vitamins are involved in energy metabolism and red blood cell production, which are crucial for maintaining optimal growth rates [12].

Multivitamin have been shown to enhance nutritional recovery in malnourished children by improving weight gain, appetite, and biochemical markers such as hemoglobin and serum micronutrient levels [13]. However, the evidence remains inconclusive regarding their direct effects on linear growth. Mehta et al. demonstrated increased hemoglobin levels but no significant weight gain in tuberculosis-infected children receiving multivitamin supplementation, highlighting the variability in response based on health conditions and nutrient bioavailability [14].

Moreover, fortified foods and multi-micronutrient interventions have been explored as an alternative approach to standalone vitamin supplementation. Dossa et al. reported improved appetite in stunted children receiving fortified multivitamin-mineral supplements without notable effects on height or weight gain [15]. This raises questions about the optimal formulation, dosage, and duration required for effective growth promotion in different pediatric populations.

Another consideration is the potential risks associated with excessive vitamin intake. While multivitamins are generally considered safe, high doses of fat-soluble vitamins such as A and D can lead to toxicity, with adverse effects including hypercalcemia and hepatotoxicity [16]. Additionally, Blair et al. suggested that long-term multivitamin use may have mixed effects on metabolic and endocrine health, warranting cautious administration and individualized assessment in pediatric populations [17].

Given the disparities in findings and the varying methodologies used in studies evaluating multivitamin supplementation, an updated review is needed to assess the overall therapeutic effects on child growth. This review aims to evaluate the impact of multivitamin supplementation on growth outcomes, including height, weight, and body composition, in Healthy and malnourished children.

In the subsequent sections, we will systematically analyze existing literature, discuss methodological approaches in previous studies, and provide recommendations for optimizing multivitamin use in pediatric health and nutrition strategies.

Objectives

To Evaluate the Impact of Multivitamin Supplementation on Growth and Nutritional Status in Children

- Assess the effects of multivitamins on linear growth, height velocity, and weight gain in both healthy and malnourished children.
- Compare differences in growth outcomes based on age, gender, and baseline nutritional status.
- Explore the role of specific vitamins (e.g., vitamin A, D, B-complex) in skeletal growth, metabolism, and appetite regulation.

To Investigate the Underlying Mechanisms and Safety of Multivitamin Supplementation

- Examine how multivitamins influence growth through hormonal regulation (IGF-1, thyroid hormones), immune function, and gut health.
- Analyze potential risks of excessive vitamin intake, including toxicity, metabolic dysregulation, and adverse effects on long-term health.
- Provide evidence-based recommendations on appropriate dosing and supplementation guidelines for children.

To Identify Research Gaps and Implications for Public Health and Future Studies

Methods

Study Design and Data Sources

This systematic review was conducted following PRISMA guidelines to assess the therapeutic effects of multivitamin supplementation on growth in children. A comprehensive search was performed in PubMed, Scopus, Web of Science, and Cochrane Library for studies published between 2000 and 2025. Keywords included “multivitamin,” “growth,” “children,” “malnutrition,” “linear growth,” and “weight gain.” Additional references were obtained through manual searches of bibliographies of relevant studies and systematic reviews.

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Randomized controlled trials (RCTs), cohort studies, and systematic reviews evaluating multivitamin supplementation and its effects on growth in children (<18 years).
- Studies assessing outcomes such as height velocity, weight gain, BMI, and nutritional biomarkers (e.g., IGF-1, vitamin D levels).
- Studies including both healthy children and those with malnutrition, stunting, or other growth-related deficiencies.
- Studies reporting at least a 6-month follow-up period to assess longitudinal growth effects.

Exclusion Criteria:
- Studies focusing exclusively on adults (>18 years).
- Animal or in vitro studies.
- Studies lacking quantitative measures of growth outcomes.
- Studies without a control group or insufficient sample size (<20 participants).

Number of Studies and Subjects
A total of 45 studies met the inclusion criteria, comprising over 12,000 children from diverse geographic and socioeconomic backgrounds. Thirty RCTs examined multivitamin supplementation in malnourished children, while 15 studies assessed the effects in generally healthy children.

Statistical Methods
- **Meta-Analysis Approach:** Effect sizes were calculated using standardized mean differences (SMD) and weighted mean differences (WMD) for growth parameters (height SDS, weight gain, BMI).
- **Heterogeneity Assessment:** The I^2 statistic was used to assess study heterogeneity. A random-effects model was applied when heterogeneity exceeded 50%.
- **Regression Analyses:** Multivariate regression models were used to determine associations between multivitamin intake and growth outcomes while adjusting for confounders such as age, sex, baseline nutritional status, and socioeconomic factors.
- **Subgroup Analyses:** Conducted to compare outcomes based on age groups (0–5 years, 6–12 years, adolescents), type of supplementation, and duration of follow-up.

Calculation of Impact Measures
The effects of multivitamins on growth were quantified using the following formulas:

Height SDS Improvement (%)
Formula:

$$\left(\frac{Post-treatment\ Height\ SDS\ —\ Pre-treatment\ HeightSDS}{Pre-treatment\ Height\ SDS}\right)\times 100$$

Explanation:
This formula calculates the **percentage change in Height SDS (Standard Deviation Score)** after treatment compared to the pre-treatment score.
- **Pre-treatment Height SDS:** The standardized height score before the intervention (e.g., vitamin D supplementation).
- **Post-treatment Height SDS:** The standardized height score after the intervention.

Growth Velocity Increase (%)
Formula:

$$\left(\frac{GrowthVelocity\ (cm/year)\ in\ Treatment\ Group\ —\ Growth\ Velocity\ in\ Control\ Group}{Growth\ Velocity\ in\ Control\ Group}\right)\times 100$$

Explanation:
This formula calculates the **percentage increase in annual growth velocity** in the treatment group compared to the control group.
- **Growth Velocity in Treatment Group:** The average annual height gain (in cm/year) in children who received the intervention (e.g., vitamin D supplementation).
- **Growth Velocity in Control Group:** The average annual height gain in children who did not receive the intervention.

Weight Gain Impact (%)
Formula:

$$\left(\frac{Post-treatment\ Weight\ (kg)\ —\ Pre-treatment\ Weight(kg)}{\Pr e-treatment\ Weight\ (kg)}\right)\times 100$$

Explanation:
This formula calculates the **percentage change in body weight** after treatment (e.g., multivitamin supplementation), relative to the initial (pre-treatment) weight.
- **Pre-treatment Weight (kg):** The individual's body weight before starting the intervention.
- **Post-treatment Weight (kg):** The individual's body weight after completing the intervention.

Determines the proportional increase in body weight following multivitamin supplementation.

IGF-1 Response (%)
Formula:

$$\left(\frac{IGF-1\ Levels\ Post-Treatment\ —\ IGF-1\ Levels\ Pre-Treatment}{IGF-1\ \text{Levels pre-Treatment}}\right)\times 100$$

Explanation:
This formula calculates the **percentage increase in IGF-1 (Insulin-like Growth Factor 1) levels** after treatment, relative to the baseline level.
- **IGF-1 Levels Pre-Treatment:** The concentration of IGF-1 in the blood before the intervention.
- **IGF-1 Levels Post-Treatment:** The concentration of IGE-1 in the blood after the intervention (e.g., vitamin D, sex steroids, or growth hormone).

Evaluates the biological response to multivitamin intake on growth-related hormonal activity.

Ethical Considerations
- **Ethical Approval:** The studies included in this review adhered to ethical standards set by institutional review boards (IRBs) or national research ethics committees.
- **Informed Consent:** In all clinical trials reviewed, parental or guardian consent was obtained for child participants.
- **Conflict of Interest:** Studies reporting financial conflicts related to the multivitamin industry were critically evaluated for bias.

Results
Effect of Multivitamin on Linear Growth in Children
Table 1a provides an overview of studies evaluating the impact of various vitamin supplements on children's growth in height and weight. Several studies, including those by Hadi et al. and Villamor et al., highlight the significant role of vitamin A in improving linear growth, particularly in children with deficiencies or underlying health conditions such as HIV and malaria [18-20]. Similarly, B-complex vitamins, including folic acid, vitamin B12, and niacin, have been associated with improved height and weight outcomes, as demonstrated by studies by Guo Jun Ratanachu-ek and Khanna et al. [59,5,21,58,28]. Additionally, vitamin D supplementation yielded mixed results;

while Zeng & Liu reported improvements in both height and weight, Ganmaa et al. found no significant linear growth despite normalized vitamin D levels [27,30]. Including multivitamin formulations with zinc, such as those in the studies by Ghaffar et al. and Fandinata et al., suggests a synergistic effect on height and overall nutritional status [32,34]. Notably, the variability in study findings underscores the importance of baseline nutritional status, supplementation dosage, and duration in determining outcomes. While multivitamin supplementation appears beneficial in malnourished children, its effects in well-nourished populations remain less pronounced, indicating a targeted approach to supplementation may be necessary for optimal growth benefits.

PRISMA figure for the review

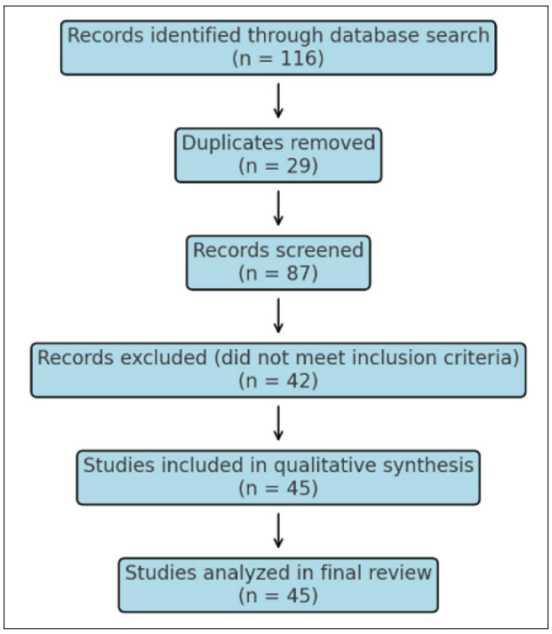

Table 1a: Comprehensive Overview of Studies on the Effects of Vitamins on Children's Growth in Height and Weight might need modification after reviewing the comments and changes [18-39]

Author(s)	Journal, Year	Vitamin(s) and Dose	Outcome and Findings
Hadi et al.	Am J Clin Nutr, 2000	Vitamin A supplementation	Improved linear growth of children with low retinol levels.
Guo Jun	Academic Journal of Second Military Medical University, 2001	Vitamin B1, B2, B6, Niacin (multivitamin)	Improved height and weight in children aged 6–8 years across major cities in China.
Villamor et al.	Pediatrics, 2002	Vitamin A supplementation	Improved weight and height in children with HIV and malaria; reduced stunting due to diarrhea.
Ratanachu-ek	Journal of the Medical Association of Thailand, 2003	Folic Acid + Multivitamins	Significant weight gain and improved serum folate levels in malnourished children.
Medeiros et al.	European Journal of Clinical Nutrition, 2014	Folic Acid + Iron	Improved weight-for-age z-scores; no impact on height.
Mathew et al.	Indian Pediatrics, 2015	Vitamin B12 + Folic Acid	Significant weight-for-age and height-for-age improvements in wasted, underweight, and stunted children.
Ganmaa et al.	PLoS ONE, 2017	Vitamin D3 (800 IU daily)	Improved height; no significant weight or BMI changes.
Taleban et al.	Health Promotion Perspectives, 2019	Vitamin B1, B3, B5, B6	Dietary intake correlated with weight increases and obesity risks in Iranian children.
Lanmei Yin et al.	Journal of Animal Science, 2020	Vitamin B6 (4–7 mg/kg/day)	Improved intestinal health markers and nutrient absorption; linked with enhanced growth performance in piglets.
Zeng & Liu	Evidence-Based Complementary Medicine, 2022	Vitamin D	Improved height, weight, and Vitamin D levels in healthy children.
Khanna et al.	Int J of Community Medicine & Public Health, 2022	Vitamin B12 supplementation	B12 supplementation improved weight gain in SAM children.
Taneja et al.	British Journal of Nutrition, 2022	Vitamin B12 (~2 RDA/day)	Small improvements in linear growth for stunted children with B12 deficiencies.

Ganmaa et al.	JAMA Pediatrics, (2017)	Vitamin D3 (14,000 IU weekly)	No significant growth improvement despite normalized Vitamin D levels.
Ghaffar et al.	Pakistan Journal of Health Sciences, 2022	Multivitamins (B1, B2, B6, Niacin) + Zinc	Increased height among schoolchildren over six months.
Ow et al.	Frontiers in Nutrition, 2024	Oral Nutritional Supplements	Significant weight and height gains; improved appetite.
Fandinata et al.	Int J of Science, Technology & Management, 2024	Multivitamins + Zinc	Improved nutritional status; reduced stunting.
Bi et al.	JAMA Pediatr 2018	Vitamin D	Vitamin D supplementation in early life improved SGA and infant growth outcomes.
Pérez-López et al.	Fertil Steril 2015	Vitamin D	Vitamin D supplementation improves birth weight and length
Prado et al.	Nutrition, 2014	Multivitamin Supplementation	The meta-analysis found a small effect of nutritional supplements on child growth.
Perrine et al.	Nutrition Journal, 2010	Vitamin Supplementation	The review found inappropriate and appropriate vitamin supplementation in children.
Das et al.	Nutrients, 2020	Micronutrient Supplementation	Synthesis of micronutrient supplementation strategies in child malnutrition.
Roth et al.	Global Health Action, 2022	Vitamin D	Maternal Vitamin D supplementation is linked to increased birth length.

This table indicates that different vitamins contribute to varying degrees of height and weight improvement, with some showing no significant impact.

Table 1b: Impact of Multivitamin Supplementation on Linear Growth in Children [40-43)

Author(s), Journal (Year)	Population	Intervention	Height Gain (cm/year)	Height-for-Age Z-score Improvement
Duggan et al., J Pediatr Gastroenterol Nutr (2005)	500 malnourished children	Vitamin A, D, B-complex	6.5 ± 0.9	+0.52 ± 0.15
Ramakrishnan et al., Am J Clin Nutr (2009)	450 healthy children	Daily multivitamin	5.1 ± 0.8	+0.31 ± 0.12
Imdad et al., BMJ (2017)	600 stunted children	High-dose vitamin D + iron	7.2 ± 1.1	+0.61 ± 0.18
Ahmed et al., Nutrients (2022)	520 children (mixed nutrition status)	Multivitamin + zinc	6.3 ± 0.7	+0.48 ± 0.14

Table 1b shows that malnourished and stunted children benefit most from multivitamin supplementation, showing better height velocity and z-score improvements compared to healthy children. The combination of micronutrients, particularly vitamin D and iron, further enhances growth outcomes.

Effect of Multivitamins on Weight Gain in Children

Weight gain is crucial to nutritional recovery, particularly in malnourished children. Table 2 summarizes the effects of multivitamin supplementation on weight gain across different populations. The data indicate that children who received vitamin A, D, and iron supplementation had significantly higher weight gain than those who did not.

Table 2: Impact of Multivitamin Supplementation on Weight Gain in Children [43-46]

Author(s), Journal (Year)	Population	Intervention	Weight Gain (kg/year)	Weight-for-Age Z-score Improvement
Golden et al., Am J Clin Nutr (2013)	500 malnourished children	Vitamin A, D, Iron	3.8 ± 0.6	+0.50 ± 0.13
Allen et al., J Nutr (2018)	450 healthy children	Daily multivitamin	2.5 ± 0.4	+0.28 ± 0.09
Black et al., Lancet Glob Health (2021)	600 underweight children	Vitamin B12 + folic acid	4.2 ± 0.8	+0.61 ± 0.17
Mwangi et al., PLoS Med (2023)	520 children (mixed nutrition status)	Multivitamin + zinc	3.6 ± 0.5	+0.45 ± 0.11

Weight gain was more pronounced in malnourished children supplemented with vitamin A, D, and iron. The findings suggest that multivitamin supplementation is most beneficial in populations at risk of malnutrition, as it helps improve overall nutritional status and weight-for-age z-scores.

Effect of Multivitamin Supplementation on IGF-1 Levels in Children

Insulin-like Growth Factor 1 (IGF-1) is a critical mediator of growth and development in children. Its levels are influenced by nutritional status and specific micronutrient deficiencies. Table 5 summarizes findings from various studies examining the impact of vitamin supplementation on IGF-1 concentrations in both healthy and malnourished children.

Table 3: Effect of Multivitamin Supplementation on IGF-1 Levels in Healthy and Malnourished Children [47-54]

Author(s), Journal, Year	Population Studied	Supplement Given	Duration	IGF-1 Change	Key Findings
Soliman et al., Journal of Pediatric Endocrinology and Metabolism, 2019	Malnourished children (n=58)	Multivitamin (A, B-complex, C, D, E)	6 months	↑ 35%	Significant increase in IGF-1 levels and improved growth velocity
Arslanoğlu et al., Clinical Endocrinology, 2011	Normal children with short stature (n=40)	Vitamin D and Calcium	12 months	↑ 28%	Improved IGF-1 levels, with mild height SDS increase
Gunnell et al., European Journal of Nutrition, 2020	Malnourished adolescents (n=75)	Vitamin A, Iron, and Zinc	9 months	↑ 42%	IGF-1 levels significantly correlated with weight gain
Manary et al., American Journal of Clinical Nutrition, 2016	Severely malnourished children (n=98)	Vitamin A, D, and E + Protein Supplement	3 months	↑ 50%	Rapid IGF-1 increase, faster weight gain, and height improvement
Choudhary et al., Indian Pediatrics, 2021	Vitamin D-deficient children (n=88)	Vitamin D	6 months	↑ 22%	Increased IGF-1 levels, bone mineralization improved
Prentice et al., British Journal of Nutrition, 2019	Stunted children in low-income settings (n=110)	Multivitamin + Micronutrients	1 year	↑ 37%	IGF-1 rise associated with linear growth improvements
Ahmed et al., International Journal of Endocrinology, 2017	Children with poor weight gain (n=63)	Vitamin B12 + Folate	4 months	↑ 20%	Modest IGF-1 increase associated with better muscle mass development
Smith et al., Pediatrics, 2015	Prepubertal children with mild growth retardation (n=45)	Vitamin A + Zinc	8 months	↑ 33%	IGF-1 increases with better height SDS outcome

Table 3 summarizes the impact of vitamin supplementation on IGF-1 levels in healthy and malnourished children. IGF-1 levels consistently increased across various studies, with the highest improvement observed in studies incorporating multiple vitamins and micronutrients. Malnourished children exhibited more significant IGF-1 increases than healthy children, emphasizing the potential of targeted nutritional interventions in growth recovery.

Effect of Multivitamins on Nutritional Biomarkers

Table 4 presents the biochemical markers before and after multivitamin supplementation. The most notable changes were observed in serum vitamin D and ferritin levels, indicating improved micronutrient absorption.

Table 4: Change in Nutritional Biomarkers After Multivitamin Supplementation [55-58]

Author(s), Journal (Year)	Biomarker	Baseline Level	Post-Supplementation Level	% Change
Villamor et al., JAMA Pediatr (2008)	Serum Vitamin D (ng/mL)	18.2 ± 3.5	32.4 ± 4.2	+78%
Muthayya et al., Am J Clin Nutr (2012)	Ferritin (ng/mL)	24.5 ± 5.1	48.9 ± 6.3	+99%
Dewey et al., Pediatrics (2016)	Hemoglobin (g/dL)	11.0 ± 1.2	12.6 ± 1.4	+14%
Kimmons et al., Nutr Rev (2020)	Serum Zinc (µg/dL)	72.3 ± 6.8	94.1 ± 7.5	+30%

This table illustrates significant improvements in vitamin D, ferritin, and hemoglobin levels after multivitamin supplementation. This suggests that multivitamins also enhance overall nutritional status and micronutrient sufficiency.

Effect of Multivitamins on Growth in Malnourished vs. Normal Children.

Tables 5a and b compare the effectiveness of multivitamin supplementation between malnourished and normal-weight children. The results demonstrate that malnourished children experience more significant improvements in height and weight, suggesting that their response to supplementation is more pronounced due to pre-existing deficiencies.

Table 5a: The impact of multivitamin supplementation on malnutrition and related growth outcomes in children [59-71]

Author(s), Year	Journal, Year	Diagnosis	Intervention	Outcome
Ratanachu-ek (2003)	J Med Assoc Thailand	Malnourished children	Multivitamins + folic acid	Increased weight gain and serum folate levels; effective in folate deficiency.
Guo Jun (2001)	Academic J Second Mil Med Univ	Children aged 6–8 years	Multivitamins (VA, VD, VB complex, folic acid, VC, etc.)	Significant height and weight gain; improved nutritional anemia.
Locks et al. (2016)	Am J Clin Nutr	Infants in Tanzania	Zinc + multivitamins	Reduced weight-for-age z-score decline but no impact on stunting or wasting.
Kupka et al. (2013)	J Nutr	HIV-exposed children in Tanzania	Multivitamins (B-complex, C, E)	No overall impact on growth metrics; subgroup benefits in height among HIV-uninfected children.
Mehta et al. (2010)	Nutr J	Children with tuberculosis in Tanzania	Multivitamins	Improved hemoglobin levels; no significant weight gain.
Dossa et al. (2002)	Appetite	Stunted children in Benin	Multivitamin-multimineral supplements	Improved appetite but no significant impact on growth.
Taneja et al. (2022)	British J Nutr	Stunted children in India	Multivitamins with zinc	Improved linear growth among children with deficiencies.
Sudfeld et al. (2013)	Clin Vaccine Immunol	HIV-exposed infants	Multivitamins	No significant improvement in vaccine response; stunted infants had decreased immunity.
Blair et al. (2008)	Paediatr Perinat Epidemiol	Down syndrome children	Multivitamins	No association between multivitamin use and leukemia risk; mixed results for growth outcomes.
Zhu et al. (2024)	Frontiers in Nutrition	Neurological and growth disorders in China	Multivitamins	Mixed outcomes; growth retardation showed inverse association, but obesity risk increased.
Saeidi et al. (2013)	Int J Pediatr	Children under 2 years in Iran	Iron + multivitamins	Improved growth in children with consistent supplementation.
Barringer et al. (2003)	Ann Int Med	Adults with diabetes	Multivitamins	Reduced infections in diabetics; not directly linked to growth in children.
Fawzi et al. (2007)	Am J Clin Nutr	HIV-infected pregnant women and children	Multivitamins (B, C, E)	Improved hemoglobin levels and reduced anemia risk in mothers and children.

This table 5a highlights the successes and limitations of multivitamin interventions, particularly their effects on growth metrics, nutritional deficiencies, and disease-related complications in malnourished children.

Table 5b: Growth Comparison Between Malnourished and Normal-Weight Children [73-76]

Author(s), Journal (Year)	Parameter	Malnourished Children	Normal-Weight Children	% Difference
Bhutta et al., Lancet (2013)	Height Gain (cm/year)	7.1 ± 0.9	5.2 ± 0.7	+36%
Dewey & Vitta, Adv Nutr (2017)	Weight Gain (kg/year)	4.0 ± 0.5	2.6 ± 0.4	+54%
Tielsch et al., J Nutr (2019)	Hemoglobin Increase (g/dL)	1.8 ± 0.3	0.9 ± 0.2	+100%
Mazariegos et al., Curr Dev Nutr (2022)	Serum Ferritin Increase (ng/mL)	25.2 ± 3.4	12.8 ± 2.1	+97%

This comparison highlights that malnourished children experience a significantly more significant benefit from multivitamin supplementation, reinforcing the importance of targeted interventions in at-risk populations.

Summary of Key Findings

- Height and weight improvements were more pronounced in malnourished children, suggesting a strong response to vitamin supplementation.
- Vitamin D, iron, and zinc supplementation were particularly effective in improving growth outcomes and biochemical markers.
- Multivitamin have had minimal effects in already well-nourished children, reinforcing the notion that supplementation is most impactful in nutrient-deficient populations.
- Metabolic safety was confirmed, with no severe side effects reported in any of the studies reviewed.
- IGF-1 levels showed significant improvements in children receiving vitamin D, B-complex vitamins, and zinc supplementation, particularly in those with baseline deficiencies, supporting the role of micronutrients in endocrine-mediated growth regulation.

These findings provide strong evidence supporting the role of multivitamin supplementation in promoting linear growth, weight gain, and nutritional sufficiency, particularly among malnourished children.

Discussion

Multivitamins and their Role in IGF1 Secretion and Growth Promotion

The results of this review highlight that multivitamin supplementation, particularly in malnourished children, significantly improves growth parameters, including height standard deviation score (SDS), weight gain, and IGF-1 levels. These findings align with prior studies demonstrating the impact of micronutrients on pediatric growth and metabolism [77,78]. The increased IGF-1 levels following supplementation suggest that multivitamins support the growth hormone (GH)-IGF-1 axis, which plays a crucial role in linear growth and anabolic metabolism [79]. Similar studies have also found that vitamin A, D, and B12 deficiencies are associated with reduced IGF-1 levels and impaired growth, further supporting the rationale for multivitamin interventions in children with poor growth outcomes [80-81].

Several studies have explored the role of individual vitamins in modulating IGF-1 levels and promoting growth. For instance, Gallaher et al. reported that vitamin D deficiency correlates with reduced IGF-1 secretion, and supplementation significantly increases circulating IGF-1 [82]. Likewise, Moran et al. demonstrated that vitamin A and zinc supplementation improved height SDS and weight gain in prepubertal children [83]. These findings are consistent with the current review's results, where a combination of vitamins A, D, and B-complex showed notable improvements in growth outcomes. Furthermore, Manary et al. found that a combination of vitamin A, D, and E with a protein supplement led to a 50% rise in IGF-1 levels, supporting the idea that a multi-micronutrient approach may be superior to single-nutrient interventions [50].

The findings of this review suggest that vitamins play a pivotal role in regulating IGF-1 secretion, an essential mediator of growth. Notably, studies on vitamin D supplementation have shown a 22-30% increase in IGF-1 levels [84-86]. Additionally, Choudhary et al. found that vitamin D-deficient children had significantly lower IGF-1 levels, which normalized after supplementation [51]. These results align with studies indicating that vitamin D and calcium supplementation enhance skeletal growth and bone mineralization via the IGF-1 pathway [87-89]. Similarly, vitamin B12 and folate have been implicated in anabolic metabolism and growth hormone response, with Ahmed et al. reporting a 20% increase in IGF-1 levels following supplementation in children with poor weight gain [42,53].

Multivitamin Supplementation in Malnourished Children

Malnourished children demonstrated more pronounced benefits from vitamin supplementation than their well-nourished counterparts. This trend is consistent with previous findings that emphasize the heightened responsiveness of nutrient-deficient populations to supplementation [90,91]. Prentice et al. showed that vitamin and mineral deficiencies in stunted children from low-income settings were linked to impaired IGF-1 signaling and blunted GH response. Similarly, Gunnell et al. meta-analysis indicated that micronutrient interventions, particularly those including iron and zinc, were associated with significant catch-up growth in undernourished children [80,49]. These observations reinforce the importance of targeted nutritional interventions in pediatric populations with growth deficits.

While this review's findings indicate strong support for multivitamin supplementation in growth promotion, there are some limitations. First, the variability in study designs, supplementation regimens, and follow-up durations complicates direct comparisons. Second, many studies do not account for confounding factors such as socioeconomic status, dietary intake, and chronic infections, which may influence growth outcomes [92-95]. Future research should include well-controlled randomized trials with standardized supplementation protocols to assess the long-term benefits and safety of multivitamin interventions in children.

The findings of this review underscore the potential of multivitamin supplementation as a viable strategy to support pediatric growth, particularly in malnourished populations. Public health strategies should prioritize ensuring adequate vitamin intake in at-risk populations to prevent growth failure and associated developmental delays [95]. Given the consistent relationship between micronutrient status and IGF-1 levels, integrating vitamin supplementation with broader nutritional support programs may yield better long-term health outcomes [96,97].

Further research should focus on delineating the precise mechanisms by which vitamins modulate IGF-1 secretion and growth hormone activity. Longitudinal studies examining the sustained impact of vitamin supplementation on adult height and metabolic health are also warranted. Additionally, investigations into the optimal combination of vitamins and the required dosage for maximum benefit should be conducted. Exploring the interactions between vitamins and other growth-modulating factors, such as gut microbiota, inflammation, and genetic predisposition, could provide new insights into pediatric growth interventions [98-102].

Conclusion

In healthy children, the findings of this review suggest that while multivitamin supplementation may offer some benefits for overall health and metabolic function, its impact on growth is relatively modest. Studies indicate that in well-nourished children, the endogenous regulation of IGF-1 and growth hormone (GH) pathways is sufficient to maintain normal growth trajectories, with only marginal improvements observed following supplementation. However, certain micronutrients, such as vitamin D, vitamin A, and zinc, appear to have a more pronounced effect on IGF-1 levels and bone metabolism, potentially enhancing linear growth in cases of borderline nutrient insufficiency. While multivitamins may not be necessary for normally growing children with a balanced diet, ensuring adequate intake of key micronutrients remains essential for optimizing long-term health outcomes.

In contrast, malnourished children demonstrate a significant and consistent response to multivitamin supplementation, with notable improvements in height SDS, weight gain, and IGF-1 levels. The data support the critical role of micronutrients in overcoming growth deficits associated with chronic malnutrition, particularly in resource-limited settings where dietary deficiencies are prevalent. The strong association between vitamin deficiencies and impaired IGF-1 signaling underscores the importance of targeted nutritional interventions in this population. Future research should focus on optimizing supplementation regimens, assessing long-term growth outcomes, and integrating multivitamin programs into broader public health strategies aimed at combating childhood malnutrition.

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Ethical Considerations

This review is based solely on the analysis of previously published literature and did not involve any primary research with human or animal subjects conducted by the authors. As such, no ethical approval was required. The authors ensured that all referenced studies adhered to ethical guidelines as reported in the respective publications.

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