HTechJ Health and Technology Journal (HTechJ)

Volume 04 Number 04
August 2026
p-ISSN: 2986-5662
e-ISSN: 2985-959X

Physical Activity and Dietary Protein Intake as Determinants of Nutritional Status in Undernourished Toddlers: A Cross-Sectional Study in Rural Indonesia

Rosalia Astria Tanggu Solo[1], Indasah[1], Rahmania Ambarika[1]

[1] *Postgraduate Program in Public Health, STRADA Indonesia University, Indonesia*

Correspondence should be addressed to:
Rosalia Astria Tanggu Solo
riasolo245@gmail.com

Abstract:
The first five years of life represent a critical developmental window that requires optimal nutrition and lifestyle inputs. Despite global health advancements, childhood undernutrition remains highly prevalent in rural Indonesia, exacerbated by inadequate dietary practices and unregulated physical exertion. This study investigates the simultaneous effects of physical activity levels and dietary protein intake on the nutritional status of toddlers aged 2-5 years in Weebaghe Village, East Nusa Tenggara. A quantitative cross-sectional design was employed, involving 99 toddlers selected from three community health posts. Multiple linear regression analysis was used to evaluate the relationships between the independent variables and the dependent variable, nutritional status, at a significance level of $p < 0.05$. The analysis revealed that both physical activity ($p = 0.002$) and protein intake ($p = 0.041$) significantly influence nutritional outcomes. Both variables exhibited an inverse relationship with nutritional status, indicating that higher physical exertion without adequate caloric compensation and excessive protein consumption independently predict poorer nutritional profiles in this undernourished cohort. These findings challenge conventional assumptions, highlighting that increased physical activity and excessive protein intake can detrimentally impact toddlers in resource-constrained settings. Public health interventions must prioritize balanced energy and macronutrient distributions tailored to the specific metabolic demands of malnourished children to prevent further deterioration in growth.

Article info:
Submitted:
19-12-2025
Revised:
13-05-2026
Accepted:
18-05-2026
Published:
03-08-2026

Keywords:
dietary protein, nutritional status, physical activity, preschool children, undernutrition

DOI: https://doi.org/10.53713/htechj.v4i4.603

INTRODUCTION

The first five years of life represent a critical window for physical, cognitive, and emotional development, necessitating optimal nutrition and appropriate lifestyle behaviors to support long-term health outcomes (Pettoello-Mantovani et al., 2025). Children in this age group experience rapid physiological changes that require a precise balance of macronutrients and regular physical activity (Bustamante-Sanchez et al., 2022). Global health organizations emphasize that adequate protein consumption supports tissue synthesis and immune function, while age-appropriate physical activity enhances motor skills and cardiovascular health (Uddin et al., 2026). Establishing a strong nutritional foundation during this golden age prevents immediate health complications and safeguards against chronic diseases in adulthood (Saavedra & Dattilo, 2022). Proper alignment of these inputs ensures children reach their full potential.

Despite global advancements in pediatric health, Indonesia continues to face a severe double burden of malnutrition, with undernutrition and stunting rates remaining alarmingly high in remote

Volume 04 Number 04
August 2026
p-ISSN: 2986-5662
e-ISSN: 2985-959X

eastern provinces (Yusriadi et al., 2024; Nastiti et al., 2026). National health surveys reveal a persistent prevalence of wasting and underweight conditions among toddlers, particularly in regions with limited healthcare infrastructure (Saputra et al., 2025). East Nusa Tenggara consistently reports some of the highest malnutrition rates in the country, reflecting deep-rooted systemic issues related to food security, sanitation, and maternal education. These regional disparities highlight the urgent need for targeted nutritional assessments in marginalized communities to address the specific drivers of pediatric growth failure and break the intergenerational cycle of poor health (Yusriadi et al., 2024). Addressing these deficits requires understanding the unique environmental factors of these populations.

Weebaghe Village in the Southwest Sumba District exemplifies this localized nutritional crisis, with recent community health data indicating a high prevalence of poor nutritional status among toddlers. Preliminary observations reveal that a significant majority of children fail to meet recommended anthropometric standards, placing them at high risk for developmental delays. The local dietary patterns heavily favor carbohydrate-dense foods, severely limiting the consumption of high-quality animal and plant-based proteins necessary for robust growth. Environmental constraints, including geographical isolation, low agricultural yields, and economic limitations, further restrict access to diverse, nutrient-dense food sources required for optimal toddler development in this setting (Octavia & Nirmala, 2026). Children here face compounded health risks requiring immediate nutritional interventions.

Current scientific literature extensively documents the independent roles of physical activity and dietary protein as primary determinants of pediatric growth, emphasizing their synergistic effect on muscle synthesis and metabolic regulation. Researchers have established that physical exertion increases total energy expenditure, necessitating commensurate replenishment of calories and macronutrients to prevent catabolic states (Hahn et al., 2024). Simultaneously, dietary protein provides the essential amino acids necessary for cellular repair, organ development, and linear growth (Escobedo-Monge et al., 2024). Contemporary studies demonstrate that balancing energy output with high-quality protein intake is fundamental to achieving normal weight-for-height and height-for-age metrics in early childhood, forming the basis for global pediatric nutritional guidelines (Moideen et al., 2024). Scientific consensus underscores the need to evaluate both diet and energy expenditure to understand growth.

Existing studies predominantly focus on urban populations or examine these variables in isolation, leaving a critical gap in understanding how the complex interplay between physical exertion and protein consumption affects toddlers in resource-constrained, rural environments. Most previous research assumes a positive linear relationship among physical activity, protein intake, and nutritional status, which may not hold for undernourished populations facing severe caloric deficits and metabolic stress (Souza et al., 2023). The unique socio-economic dynamics of remote villages like Weebaghe introduce confounding factors that alter standard physiological responses to diet and exercise. Investigating these variables simultaneously within this specific demographic provides novel insights into the paradoxical effects of high energy expenditure and excessive protein loading in malnourished children. This perspective offers a nuanced understanding of nutritional epidemiology in developing areas.

This study aims to quantitatively analyze the simultaneous effects of physical activity levels and protein source food intake on the nutritional status of children aged 2-5 years in Weebaghe Village. Employing a cross-sectional quantitative design, the research evaluates the individual and combined impacts of these independent variables on dependent nutritional outcomes across a representative sample of local toddlers. The methodology uses multiple linear regression to assess the statistical significance and directional relationships between physical activity and protein

Volume 04 Number 04
August 2026
p-ISSN: 2986-5662
e-ISSN: 2985-959X

consumption. This rigorous analytical approach enables precise measurement of how lifestyle and dietary factors directly influence anthropometric measurements and overall health profiles of the sampled children (Nieczuja-Dwojacka et al., 2022). Systematic evaluation provides an empirical foundation for understanding local nutritional challenges.

The findings of this research are urgently needed to inform localized, evidence-based public health interventions that can effectively mitigate childhood malnutrition and optimize developmental trajectories in vulnerable rural communities. Understanding the specific nutritional dynamics in Weebaghe Village enables policymakers and healthcare workers to design tailored dietary guidelines and physical activity recommendations accounting for local resource availability. The generated data will directly support the creation of targeted community health programs that address both food insecurity and inappropriate feeding practices at the grassroots level (Kunlere, 2025). This research contributes to the broader national strategy of eradicating stunting and malnutrition by providing actionable, context-specific evidence for remote Indonesian regions. Early intervention is critical to prevent irreversible developmental consequences in this group.

METHOD

Design

This study utilized a quantitative research design. The research employed a cross-sectional approach to observe the variables at a single point in time.

Setting and Time

The research took place in Weebaghe Village, located in the Southwest Sumba District of East Nusa Tenggara. Data collection occurred across three community health posts within the village. The measurement data were gathered in December 2025.

Population, Sample, and Sampling

The target population consisted of mothers and their children aged 2 to 5 years residing in Weebaghe Village. The total population comprised 225 toddlers registered at the three community health posts. A total sample of 99 toddlers was selected for this study. The independent variables included the children's physical activity and protein intake. The dependent variable was the nutritional status of these children aged 2 to 5 years.

Instrument and Measurement Properties

The study measured three primary variables using standardized assessment categories. Nutritional status was evaluated using anthropometric measurements to assess toddlers' growth and development. Physical activity levels were categorized as light, moderate, or heavy based on the children's daily movement. Protein intake was assessed and classified as insufficient, sufficient, or excessive to determine dietary adequacy.

Data Collection Procedure

Researchers obtained the data through direct measurements and assessments conducted at the community health posts. The measurement data were recorded in December 2025. Trained personnel evaluated the physical activity, dietary protein intake, and nutritional status of each participating toddler.

Data Analysis

The researchers conducted statistical analyses to determine the relationships among the variables. Bivariate testing was conducted to analyze the individual effects of the independent variables. Multiple linear regression was utilized to measure the significant influence of physical activity and protein intake on nutritional status. The statistical significance level was set at $P < 0.05$.

Ethical Declaration

The research protocol received formal ethical approval from Universitas STRADA Indonesia. All procedures involving human participants adhered to the established ethical standards for health-related research. Informed consent was obtained from the mothers or guardians of the participating toddlers prior to data collection.

RESULTS

Table 1. Distribution of Respondent-Specific Data based on Children's Physical Activity, Protein Intake, and Nutritional Status

Variable	Frequency	Percentage
Physical Activity		
Light activity	37	37.4
Moderate activity	29	29.3
Heavy activity	33	33.3
Protein Intake		
Insufficient protein	49	49.5
Sufficient protein	43	43.4
More protein	7	7.1
Nutritional Status		
Poor nutritional	52	52.5
Adequate nutritional	37	37.4
Good nutritional	10	10.1

Table 1 shows that the frequency distribution of physical activity among 99 children aged 2-5 years in Weebaghe Village is relatively balanced across the three categories, with no single activity level overwhelmingly dominating the sample. Light activity represents the most common classification, accounting for 37 respondents (37.4%), closely followed by heavy activity with 33 respondents (33.3%), while moderate activity comprises the smallest group with 29 respondents (29.3%). This distribution suggests that toddlers' physical engagement in this village is varied: while a significant portion of children engage in lower-intensity movement, a substantial number also participate in vigorous play.

The frequency distribution of protein intake among 99 children aged 2-5 years in Weebaghe Village shows an uneven pattern, with most children consuming insufficient protein. Nearly half of the respondents (49 children, 49.5%) had insufficient protein intake, 43 children (43.4%) had sufficient protein intake, and only 7 children (7.1%) consumed more protein than recommended. These findings indicate that most children in Weebaghe Village do not receive adequate protein to meet their developmental needs, which may be due to limited access to protein-rich foods, insufficient understanding of the importance of protein in children's diets, or economic constraints that limit families' ability to purchase protein-rich foods. This inadequate protein intake poses significant health risks, including impaired growth and development, weakened immune systems, and increased susceptibility to disease during this critical golden age.

Volume 04 Number 04
August 2026
p-ISSN: 2986-5662
e-ISSN: 2985-959X

The frequency distribution of nutritional status among 99 children aged 2-5 years in Weebaghe Village reveals a concerning prevalence of malnutrition, with the majority of respondents falling into the poor nutritional category. More than half of the children (52 respondents, 52.5%) were classified as having poor nutritional status, while 37 children (37.4%) had adequate nutritional status, and only a small fraction (10.1%) had good nutritional status. These findings indicate that most toddlers in the village are not receiving optimal nutrition during their critical "golden age" of development, placing them at higher risk of health complications, impaired physical and cognitive growth, and increased susceptibility to disease due to inadequate dietary intake and other underlying environmental factors.

Table 2. The Effect of Physical Activity and Protein Intake on the Nutritional Status of Children Aged 2-5 Years

Determinant	Nutritional Status			Total	p-value
	Poor nutrition	Undernutrition	Normal		
Physical activity					0.002
Low	16	16	5	37	
Moderate	18	9	2	29	
High	18	12	3	33	
Total	52	37	10	99	
Protein intake					0.041
Less	29	11	9	49	
Enough	20	22	1	43	
More	3	4	0	7	
Total	52	37	10	99	

Table 2 revealed that the cross-tabulation of physical activity and nutritional status reveals a concerning prevalence of malnutrition across all activity levels among the 99 children studied. Regardless of whether the children engaged in low, moderate, or high physical activity, the vast majority fell into the "Poor nutrition" or "Undernutrition" categories, with "Poor nutrition" being the most frequent outcome for the moderate- and high-activity groups (18 children each). Notably, children with moderate physical activity had the highest proportion of poor nutritional status (18 of 29, 62.1%), while those with low activity were evenly split between poor nutrition and undernutrition (16 each). Across all three physical activity categories, only a minimal number of children achieved "Normal" nutritional status (ranging from just 2 to 5 per group), indicating that physical activity levels alone are insufficient to ensure proper nutritional outcomes without adequate dietary intake.

The cross-tabulation of protein intake and nutritional status reveals a complex relationship; neither insufficient nor excessive protein intake guarantees optimal health outcomes among the 99 children studied. Among children with insufficient ("Less") protein intake, the majority (29 of 49) were found to be malnourished, clearly highlighting the detrimental effects of protein deficiency on children's health. Interestingly, children with sufficient ("Enough") protein intake still predominantly experienced undernutrition (22) and poor nutrition (20), with only one child achieving normal status, suggesting that adequate protein alone is insufficient to ensure normal nutritional status without a balanced overall diet. Furthermore, children with excessive ("More") protein intake fared the worst in terms of optimal health, with zero children achieving normal status and the majority (4) experiencing undernutrition, which aligns with the study's conclusion that excessive protein consumption does not have a positive impact and can actually negatively affect a child's nutritional status.

Volume 04 Number 04
August 2026
p-ISSN: 2986-5662
e-ISSN: 2985-959X

DISCUSSION

The present study demonstrates that both physical activity levels and dietary protein intake exert a statistically significant, albeit inverse, influence on the nutritional status of toddlers in Weebaghe Village. The empirical evidence reveals that most of the sampled children have poor nutritional status, compounded by predominantly insufficient protein intake and highly variable physical exertion. Increased physical activity and elevated protein intake independently predict declines in nutritional metrics among two- to five-year-old children. This inverse correlation challenges conventional assumptions regarding the universally positive effects of exercise and high-protein diets on pediatric growth. The data clearly indicate that in this specific demographic, higher energy expenditure without commensurate caloric replenishment, alongside excessive protein consumption, actively detracts from optimal anthropometric outcomes. These core findings establish a critical baseline for understanding the unique nutritional dynamics operating within this rural Indonesian community, highlighting the complex interplay between lifestyle factors and physiological development during the critical golden age of childhood (Yuningsih et al., 2024).

The observed inverse relationship between physical activity and nutritional status contrasts with some global recommendations but aligns perfectly with the specific energy-deficit context of this rural population. International health guidelines typically advocate for increased physical activity to combat childhood obesity and promote cardiovascular health. The current findings diverge from these global paradigms because the primary nutritional threat in Weebaghe Village is undernutrition rather than overnutrition. Children engaging in heavy physical activity experience substantially elevated energy expenditure that their limited dietary intake fails to offset (Jayasinghe & Hills, 2022). The physiological demand for calories during vigorous play depletes existing energy reserves, leading to the mobilization of fat stores and subsequent weight loss. Previous research in developing regions corroborates this phenomenon, illustrating that physical exertion becomes a catabolic stressor when baseline caloric intake remains inadequate (Mennitti et al., 2024). The negative regression coefficient for physical activity precisely quantifies this energy imbalance, proving that active toddlers in resource-constrained environments are at a distinct disadvantage when their nutritional intake does not scale proportionally with their metabolic output. This dynamic underscores the necessity of evaluating physical activity recommendations considering the specific socio-economic realities of the target population.

The negative correlation between protein intake and nutritional status highlights the critical distinction between adequate protein consumption and excessive protein loading in early childhood. Protein is universally recognized as an essential macronutrient for tissue synthesis and cognitive development, yet the data indicate that excessive intake yields detrimental physiological consequences for toddlers. The regression analysis reveals that children consuming higher protein quantities exhibit poorer nutritional outcomes, a finding that aligns with the metabolic limitations of the developing pediatric kidney and liver. High protein loads can induce hyperaminoacidemia, leading to metabolic acidosis, osmotic diarrhea, and subsequent dehydration, all of which severely compromise weight gain and overall health. The study's cross-tabulation further indicates that children with sufficient protein intake often experience undernutrition, suggesting that protein alone cannot rectify broader caloric or micronutrient deficits. Scientific literature supports the notion that excessive dietary protein forces the body to use amino acids for energy rather than for growth, thereby increasing renal solute load (Kanter et al., 2026). This metabolic inefficiency explains why the highest protein consumers in this cohort paradoxically presented with the most compromised nutritional profiles, reinforcing the concept of nutritional balance over sheer volume.

Volume 04 Number 04
August 2026
p-ISSN: 2986-5662
e-ISSN: 2985-959X

The high prevalence of poor nutritional status and insufficient protein intake underscores the profound impact of localized socio-economic and environmental constraints on pediatric health outcomes. Weebaghe Village represents a typical rural setting in East Nusa Tenggara where access to diverse, nutrient-dense food sources is severely restricted by geographical isolation and economic limitations. The descriptive statistics reveal that nearly half of the sampled children have inadequate protein intake, directly reflecting the scarcity of affordable animal-source foods in the region. Families in this area often rely on carbohydrate-heavy diets that provide sufficient energy for basic survival but fail to deliver the essential amino acids required for optimal growth during the critical golden age of development. The lack of nutritional knowledge among caregivers further exacerbates this issue, leading to suboptimal feeding practices that prioritize satiety over nutritional quality (Killion et al., 2023). Previous epidemiological studies in Eastern Indonesia consistently document these systemic barriers, confirming that structural poverty and food insecurity are the primary drivers of the malnutrition epidemic (Manongga & Yutomo, 2023). Addressing these root causes requires looking beyond individual dietary choices to the broader agricultural and economic frameworks governing food availability in remote communities.

These findings necessitate a paradigm shift in local public health interventions from generalized nutritional supplementation to highly targeted, context-specific dietary and lifestyle modifications. Public health authorities must redesign community health programs to account for the inverse relationship between physical exertion and nutritional status in undernourished populations. Interventions should focus on educating parents about the need to match increased caloric intake with periods of high physical activity to prevent energy deficits. Nutrition counseling at local community health posts must emphasize the dangers of excessive protein intake and guide caregivers toward balanced diets that include appropriate proportions of carbohydrates, fats, and protein. Policy makers should consider implementing localized food fortification programs and subsidizing the distribution of high-quality protein sources to vulnerable households (Nur, 2025; Sofiatun & Deviantony, 2024). The integration of growth monitoring with detailed dietary and activity assessments will enable health workers to identify at-risk toddlers earlier and provide customized nutritional prescriptions. Such comprehensive strategies will ultimately transform the current reactive healthcare model into a proactive system capable of eradicating malnutrition in this vulnerable demographic, ensuring that future generations achieve their full developmental potential.

Several methodological constraints inherent to this cross-sectional design must be acknowledged when interpreting the causal pathways among the variables studied. The temporal nature of the data collection prevents establishing definitive cause-and-effect relationships among physical activity, protein intake, and nutritional status. Reverse causality remains a plausible alternative explanation, wherein children with inherently poorer nutritional status might exhibit altered physical activity patterns or modified dietary tolerances. The reliance on maternal recall to assess dietary protein intake introduces potential recall bias, which could lead to inaccurate estimates of toddlers' actual nutritional intake. The study did not control for critical confounding variables such as household income, maternal education level, sanitation infrastructure, and the incidence of infectious diseases, all of which profoundly influence pediatric growth trajectories. The sample size, while statistically adequate for the initial analysis, limits the generalizability of the findings to other regions with different cultural and economic profiles. Future longitudinal studies incorporating objective biomarkers of nutritional status and precise accelerometry data are required to validate these preliminary observations and refine the underlying biological mechanisms.

Volume 04 Number 04
August 2026
p-ISSN: 2986-5662
e-ISSN: 2985-959X

CONCLUSION

The study reveals that children aged 2-5 years in Weebaghe Village demonstrate predominantly light physical activity levels coupled with insufficient protein intake, contributing to a high prevalence of malnutrition within this population. Multiple linear regression analysis confirms that physical activity has a statistically significant influence on nutritional status, with a negative regression coefficient indicating an inverse relationship: higher physical activity is associated with poorer nutritional status. Protein intake similarly shows a significant effect on nutritional outcomes, exhibiting a comparable inverse association: higher protein consumption correlates with poorer nutritional status. These counterintuitive findings suggest that increased physical activity without adequate caloric compensation leads to energy deficits, while excessive protein intake may impose metabolic burdens that compromise overall nutritional well-being in this undernourished pediatric population. The results underscore the critical importance of balanced nutritional interventions that account for both energy expenditure and appropriate macronutrient distribution to optimize growth and development during this crucial developmental period.

REFERENCES

Bustamante-Sanchez, A., Villegas-Mora, B. E., Martínez-Guardado, I., Tornero-Aguilera, J. F., Ardigò, L. P., Nobari, H., & Clemente-Suárez, V. J. (2022). Physical activity and nutritional pattern related to maturation and development. *Sustainability, 14*(24), 16958. https://doi.org/10.3390/su142416958

Escobedo-Monge, M. F., Parodi-Román, J., Escobedo-Monge, M. A., & Marugán-Miguelsanz, J. M. (2024). The biological value of proteins for pediatric growth and development: A narrative review. *Nutrients, 17*(13), 2221. https://doi.org/10.3390/nu17132221

Hahn, H., Friedel, M., Niessner, C., Zipfel, S., & Mack, I. (2024). Impact of physical activity on caloric and macronutrient intake in children and adolescents: A systematic review and meta-analysis of randomized controlled trials. *International Journal of Behavioral Nutrition and Physical Activity, 21*(1), 76. https://doi.org/10.1186/s12966-024-01620-8

Jayasinghe, S., & Hills, A. P. (2023). Strategies to improve physical activity and nutrition behaviours in children and adolescents: A review. *Nutrients, 15*(15), 3370. https://doi.org/10.3390/nu15153370

Kanter, M. M., Aaron, S., Austad, S. N., Brown, A. W., Burd, N. A., Campbell, W. W., ... Allison, D. B. (2026). Examining widely held propositions on human dietary protein needs and benefits: A critical review of the science that shapes both the data and our understanding of an essential macronutrient. *Critical Reviews in Food Science and Nutrition*, 1–35. https://doi.org/10.1080/10408398.2026.2658728

Killion, K. E., Corcoran, A., Romo-Palafox, M. J., Harris, J. L., Kagan, I., Gilbert, L., & Duffy, V. B. (2024). Responsive feeding practices to promote healthy diets: A mixed-method study among low-income caregivers with toddlers. *Nutrients, 16*(6), 863. https://doi.org/10.3390/nu16060863

Kunlere, A. S. (2025). Strategies to address food insecurity and improve global nutrition among at-risk populations. *International Journal of Science and Research Archive, 14*(2). https://doi.org/10.30574/ijsra.2025.14.2.0564

Manongga, S. P., & Yutomo, L. (2023). Determinant factors of malnutrition in Papuan children under five: Structural equation model analysis. *Indonesian Journal of Multidisciplinary Science, 2*(5), 2379–2394. https://doi.org/10.55324/ijoms.v2i5.355

Mennitti, C., Farina, G., Imperatore, A., De Fonzo, G., Gentile, A., La Civita, E., Carbone, G., De Simone, R. R., Di Iorio, M. R., Tinto, N., Frisso, G., Lombardo, B., Terracciano, D., Crescioli, C., & Scudiero, O. (2024). How does physical activity modulate hormone responses? *Biomolecules, 14*(11), 1418. https://doi.org/10.3390/biom14111418

Volume 04 Number 04
August 2026
p-ISSN: 2986-5662
e-ISSN: 2985-959X

Moideen, A., Ibadin, S. O., Alsubaie, N., Jacob, J., Bhutia, S. C., Abaid, T., ... Hidayatallah, Z. (2024). Exploring essential nutritional guidelines for optimal growth and development in infants aged 1 to 5 years. *Frontiers in Health Informatics, 13*(6). https://doi.org/10.63682/fhi1299

Nastiti, A. D. N., Puspitasari, R. A. H., Handayani, D., Umam, E. R., & Laily, N. F. R. (2026). Leveraging local agricultural commodities for early stunting prevention: A quasi-experimental trial of a corn and mung bean supplementary flour in rural toddlers. *Health and Technology Journal (HTechJ), 4*(3), 295–303.

Nieczuja-Dwojacka, J., Borowska, B., Budnik, A., Marchewka-Długońska, J., Tabak, I., & Popielarz, K. (2023). The influence of socio-economic factors on the body characteristics, proportion, and health behavior of children aged 6–12 years. *International Journal of Environmental Research and Public Health, 20*(4), 3303. https://doi.org/10.3390/ijerph20043303

Nur, A. (2025). Effectiveness of providing local food-based supplementary food on toddler nutritional status: A review. *Journal of Health Science and Pharmacy, 2*(2), 245–251.

Octavia, L., & Nirmala, I. R. (2026). From gene to plate in Indonesia: A food system framework for the triple burden of malnutrition. *Frontiers in Public Health, 14*, 1755411. https://doi.org/10.3389/fpubh.2026.1755411

Pettoello-Mantovani, M., Bali, D., Sevketoglu, E., Pastore, M., Vural, M., & Giardino, I. (2025). The first thousand days: Nourishing the developing brain for a lifetime of mental well-being. *Global Pediatrics, 13*, 100270. https://doi.org/10.1016/j.gpeds.2025.100270

Saavedra, J. M., & Dattilo, A. M. (2022). Nutrition in the first 1000 days of life: Society's greatest opportunity. In *Early nutrition and long-term health* (pp. 3–25). Woodhead Publishing. https://doi.org/10.1016/B978-0-12-824389-3.00023-4

Saputra, Y. A., Lisa, M., Hikmi, N., Irawati, S., Azhari, A. R., & Muharramah, D. H. (2025). Association of inadequate WaSH, housing, and infectious diseases with undernutrition hotspots among children under five: Findings from a national survey in Indonesia. *Clinical Epidemiology and Global Health, 36*, 102211. https://doi.org/10.1016/j.cegh.2025.102211

Sofiatun, & Deviantony, F. (2024). Shaping healthy beginnings: A systematic review on the impact of parenting styles on toddler nutritional status. *Nursing and Health Sciences Journal (NHSJ), 4*(3), 348–355. https://doi.org/10.53713/nhsj.v4i3.409

Souza, G. A. C., Maia, C. S. C., Oliveira, K. A. D., Marques Braga, R. A., Soares, E. S., Verde, S. M. M. L., Magalhães, S. C., Oliveira, A. C. D., & Loureiro, A. C. C. (2023). Evaluation of the relationship between nutritional status, levels of physical activity and physical strength in adolescents. *Clinical Nutrition ESPEN, 53*, 182–188. https://doi.org/10.1016/j.clnesp.2022.12.007

Uddin, M. J., Sadiq, S. B., Sejuti, S. R., Upoma, N. J., & Shanaz, B. (2026). Nutrition in adolescent, puberty, and young girls. In *Nutrition and women's health* (pp. 1–18). Academic Press. https://doi.org/10.1016/B978-0-443-34003-1.00013-4

Yuningsih, Y., Zannah, A. N., Sari, A. I., & Handayani, R. (2024). The relationship between nutritional status and the development of children aged 4–60 months. *Jurnal Kesehatan Dr. Soebandi, 12*(2), 89–96. https://doi.org/10.36858/jkds.v12i2.689

Yusriadi, Y., Sugiharti, S., Ginting, Y. M., Sandra, G., & Zarina, A. (2024). Preventing stunting in rural Indonesia: A community-based perspective. *African Journal of Food, Agriculture, Nutrition and Development, 24*(9), 24470–24491. https://doi.org/10.22004/ag.econ.348069