an idea health journal
ISSN (online): 2797-0604

Determinants of Growth Among Stunted Toddlers After Animal-Based Complementary Feeding Intervention

Volume 6 No 3, Page 448-457
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Article Info:
Received:23 February, 2026
Revised: 28 April, ,2026
Accepted: 29 April, 2026

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How to Cite:
Warsini W, Kristanto B. Determinants of Growth Among Stunted Toddlers After Animal-Based Complementary Feeding Intervention. An Idea Health Journal.2026; 6(03): 448-457. https://doi.org/10.53690/ihj.v6i03.683

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Abstract

Background: Stunting is a persistent public health issue, linked to impaired growth in children, especially in developing countries. Insufficient protein intake is a primary factor limiting optimal growth in stunted toddlers. Early nutritional intervention with animal-based protein supplementation is considered a promising strategy to improve anthropometric outcomes.

Methods: The study evaluated the impact of animal-based complementary feeding on anthropometric outcomes among stunted toddlers at Community Health Center Jayengan, Surakarta. A quasi-experimental, one-group pretest–posttest design was employed, enrolling 30 stunted toddlers through purposive sampling. The intervention involved administering animal-based processed complementary feeding (MP-ASI) for 30 days. Anthropometric parameters measured included body weight, height, and mid-upper arm circumference (MUAC). Data analysis utilized the Shapiro–Wilk test for normality and paired t-test, with statistical significance set at $p < 0.05$.

Results: All anthropometric parameters showed significant improvement following the intervention. Mean body weight increased from 10.15 ± 1.20 kg to 10.85 ± 1.25 kg ($p = 0.001$). Mean height increased from 81.50 ± 2.80 cm to 82.90 ± 2.85 cm ($p < 0.001$). Mean MUAC increased from 14.80 ± 1.10 cm to 15.90 ± 1.15 cm ($p = 0.002$).

Conclusion: Animal-based complementary feeding significantly enhances anthropometric outcomes among stunted toddlers, demonstrating a moderate effect size. This intervention represents a practical and scalable approach to support stunting reduction initiatives at the primary healthcare level.

Keywords: Stunting, Animal Protein, Toddlers.

BACKGROUND

Stunting is a condition characterized by impaired growth and development in children. It's primarily caused by inadequate chronic nutrition, recurrent infections, and insufficient psychosocial stimulation. This condition can begin as early as in the womb, but typically becomes evident when the child reaches 2 years of age, a critical period encompassing the first 1000 days of life. Without "catch-up growth" efforts, stunting can lead to serious long-term consequences, including hindered motor and mental development, reduced learning abilities, and an increased risk of chronic diseases later in life, such as obesity, diabetes, and hypertension (1). Children experiencing stunting exhibit impaired physical growth and development. This is evident not only in a low nutritional status index but also in delays in speaking, walking, erupting their teeth, and achieving other crucial developmental milestones that should typically be reached at their age (2).

The causal factors of stunting are complex. They include inadequate chronic nutrition and low intake of micronutrients and macronutrients, although this study found no direct relationship between food type or nutrient intake and stunting in the studied population. Recurrent infections with long durations are also a primary cause. Furthermore, maternal/caregiver factors such as education, parenting practices, maternal age, maternal height, and antenatal care visits are highly influential. Environmental and sanitation factors, such as water sources, handwashing practices, latrine cleanliness, and family socioeconomic status, also contribute to the incidence of stunting (3).

Globally, 22% of children under five experienced stunting in 2020. Of these, 53% were from Asia, with over 11% of cases occurring in Southeast Asia. Based on the 2022 Indonesian Nutritional Status Survey (SSGI), the prevalence of stunting in Indonesia was 21.6%, which has not yet met the National Medium-Term Development Plan (RPJMN) target of 14% for 2024 (4). Recent data from the United Nations Children's Fund (UNICEF), World Health Organization (WHO), and World Bank (WB) in 2024 indicate a substantial global burden of child malnutrition, with 150.2 million children under five affected by stunting, 42.8 million wasted, and 35.5 million overweight (5). The 2024 Indonesian Nutritional Status Survey (SSGI) indicates a decrease in national stunting prevalence from 21.5% in 2023 to 19.8% in 2024. Indonesian Health Minister Budi Gunadi Sadikin reaffirmed the government's strong commitment to reducing the national stunting rate to 14.2% by 2029, in line with the National Medium-Term Development Plan (RPJMN), which was developed in collaboration with the Vice President's Secretariat and Bappenas (6). The Indonesian government has designated 17 provinces as national priorities for tackling stunting, including Central Java, with the aim of reducing the prevalence of stunting to 14% by 2024. Central Java province itself has shown progress, with stunting rates among toddlers decreasing from 27.68% in 2019 to 20.7% in 2023. This reduction is a result of multisectoral collaboration. However, despite provincial improvements, significant variations still exist at the district/city level within Central Java. For instance, in 2023, areas like Wonosobo, Pekalongan Regency, and Pekalongan City had the highest prevalence (around 28-29%), while Demak, Pemalang, and Magelang City recorded the lowest rates (around 9-15%) (7). More specifically, in Surakarta City, data from Jayengan Community Health Center as of August 2023 indicated 21 cases of stunting. Of these, 9 showed low anthropometric values, including height-for-age, weight-for-age, and mid-upper arm circumference (MUAC) for their age. This figure is considered significant, highlighting the crucial need for intervention, particularly through the provision of nutritious food, as a key effort in stunting prevention and management.

Stunting is a serious issue in Indonesia, threatening the nation's future generations and requiring appropriate intervention. The high prevalence of stunting reflects low human capital quality, contributing to Indonesia's ranking of 130th out of 199 countries in the Human Capital Index. Stunting can also impose a significant economic burden on the nation through its effects on productivity and the

healthcare system. This is particularly true given its links to nutritional problems and unstable economic conditions during the pandemic, as well as rising poverty and unemployment (8).

Child growth is closely linked to anthropometric status. If a child's growth is appropriate for their age, their anthropometric status will be normal. In nutritional science, anthropometry is a method used to assess an individual's nutritional status by measuring various human body dimensions. The most common measurements include body weight, height, and body circumferences (e.g., mid-upper arm circumference or waist circumference). This data is then compared against reference standards to identify potential nutritional deficiencies or excesses (9). A toddler's nutritional adequacy can be assessed by their body weight. Toddlers who are underweight for their ideal range may be malnourished, which can hinder their growth and development if left unaddressed. Conversely, toddlers who are overweight risk obesity, potentially leading to serious future health issues. Mid-Upper Arm Circumference (MUAC) is a practical method for assessing a toddler's nutritional status and identifying the risk of chronic energy deficiency. A MUAC tape is a simple measuring tool often used in the field for this purpose. MUAC measurements are commonly used to evaluate the nutritional status of infants and toddlers, especially in emergency situations or when accurate weight and height measurements are difficult to obtain (10).

Inadequate nutrient intake, particularly deficiencies in protein, energy, iron (Fe), and zinc (Zn), is a primary driver of stunting in children. These nutrients play a crucial role in supporting optimal child growth and development. Specifically, protein is a vital macronutrient essential for growth processes and the repair of damaged body tissues. A mere 15% increase in protein intake has been shown to correlate with rapid child development. Furthermore, the intake of animal protein has a greater impact on addressing stunting cases than plant-based protein (1). Protein consumption in Indonesia remains far from ideal, with the Adequate Protein Intake (API) falling below 80%. In fact, approximately 36.1% of the population is categorized as having severely inadequate API, according to data from the Ministry of National Development Planning/Bappenas (2019). Insufficient protein intake, especially of animal protein, has been consistently linked to nutritional problems such as stunting. Significantly, animal protein intake directly influences short stature (stunting) in children. As a macronutrient, protein plays a crucial role as a receptor affecting DNA function, thereby stimulating and controlling growth processes. The quality and quantity of protein consumed are directly proportional to insulin-like growth factor 1 (IGF-1) levels, a key mediator of growth and bone matrix formation (11).

Efforts to prevent stunting also require strong support from village governments, particularly in the socio-emotional domain. Village governments are strategically positioned and closer to the community, enabling effective daily interaction and support through local health centers (*Puskesmas*) and community health posts (*Posyandu*) (10). This research aims to examine the effect of animal protein supplementation on improving the anthropometric values (including body weight, height, and Mid-Upper Arm Circumference (MUAC) of stunted toddlers at Jayengan Community Health Center in Surakarta. Stunting is a serious public health issue that demands early intervention and prevention. Therefore, as healthcare professionals and community members, we feel a responsibility to inform parents about the significant potential of nutritional interventions, including supplementary feeding, to enhance the nutritional status of stunted toddlers, as reflected in their anthropometric values.

METHODS

Study Design

A quasi-experimental design with a pre–post test approach was utilized to assess anthropometric outcomes among stunted toddlers at Jayengan Community Health Center in Surakarta. The intervention involved administering animal-based processed complementary feeding for 30 days.

Sample/Participans

The study population consisted of stunted toddlers residing within the operational area of Jayengan Community Health Center. Thirty stunted toddlers were selected using purposive sampling based on predefined inclusion criteria. Eligible participants exhibited anthropometric indicators (height-for-age, weight-for-age, and mid-upper arm circumference) below age-specific standards. The independent variable was the provision of animal-based processed complementary feeding (MP-ASI), and the dependent variables were anthropometric outcomes, specifically body weight, height, and mid-upper arm circumference.

Instruments

Instrument validity was established through expert judgment, producing a Content Validity Index (CVI) of 0.89, indicating good validity. Reliability testing produced a Cronbach's alpha of 0.87, demonstrating high internal consistency.

Data Collection

Provision of animal-based processed food in complementary feeding refers to parents' ability to provide such foods, a skill acquired through visual media education. Growth determinants in stunted toddlers were measured by assessing anthropometric status, including body weight, height, and mid-upper arm circumference, before and after animal protein supplementation.

Data Analysis

Data analysis included the Kolmogorov–Smirnov test for normality and a paired t-test to evaluate pre- and post-intervention differences, with statistical significance set at $p < 0.05$.

Ethical Considerations

Ethical approval was obtained from the Dr. Moewardi General Hospital Health Research Ethics Committee in Surakarta (reference number 944/IV/HREC/2024).

RESULT AND DISCUSSION

Socio-Demographic Charasteristics

Table 1. Respondent Characteristics

Characteristics	N	%
Respondent's age		
2 years old	4	13,3
2 years and 3 months old	6	20,0
2 years and 5 months old	4	13,3
2 years and 6 months old	4	13,3
2 years and 7 months old	6	20,2
3 years and 3 months old	3	10,0
3 years and 7 months old	3	10,0
Total	30	100
Gender		
Female	17	56,7
Male	13	43,3
Total	30	100
Parent's Education		
Elementary school	3	10,1
Junior high school	13	43,3
Senior high school	10	33,3

Collage	4	13,3
Total	30	100
Income		
< (Rp 2.2690.070-)	20	66,7
≥ (Rp 2.2690.070-)	10	33,3
Total	30	100

Based on Table 1, the characteristics of the respondents are as follows. The toddlers' ages ranged from 2 years to 3 years and 7 months. The most common age groups were 2 years 3 months and 2 years 7 months, each accounting for 6 children (20.0%). By gender, the majority of respondents were female, totaling 17 children (56.7%), while 13 were male (43.3%). Regarding parental education, most parents had completed junior high school (43.3%), followed by senior high school (33.3%), college education (13.3%), and elementary school (10.0%). Regarding parental income, the majority of respondents' families (66.7%) earned below the Regional Minimum Wage (UMR), while 33.3% earned at or above the UMR.

Table 2. Changes in Anthropometric Measurements Before and After Intervention (n = 30)

Variable	Before (Mean ± SD)	After (Mean ± SD)	Mean Difference	p-value
Body Weight (kg)	10.15 ± 1.20	10.85 ± 1.25	+0.70	0.002
Height (cm)	81.50 ± 2.80	82.90 ± 2.85	+1.40	0.001
MUAC (cm)	14.80 ± 1.10	15.90 ± 1.15	+1.10	0.003

Based on Table 2, the results showed an overall improvement in anthropometric measurements after the intervention. The mean body weight increased from 10.15 ± 1.20 kg to 10.85 ± 1.25 kg, with a statistically significant difference ($p = 0.002$). Similarly, the mean height increased from 81.50 ± 2.80 cm to 82.90 ± 2.85 cm ($p = 0.001$). The mean mid-upper arm circumference (MUAC) also improved from 14.80 ± 1.10 cm to 15.90 ± 1.15 cm ($p = 0.003$). These findings indicate that the administration of animal-based complementary feeding significantly improved the anthropometric status of stunted toddlers.

Table 3. Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre_Weight	.121	30	.200	.962	30	.325
Post_Weight	.134	30	.178	.955	30	.210
Pre_Height	.145	30	.097	.948	30	.134
Post_Height	.138	30	.152	.952	30	.180
Pre_MUAC	.119	30	.200	.967	30	.402
Post_MUAC	.125	30	.200	.960	30	.290

Normality of the data was evaluated using both the Kolmogorov–Smirnov and Shapiro–Wilk tests. Given that the sample size was less than 50 (n = 30), the Shapiro–Wilk test was used as the primary test for assessing the data distribution. All variables, including pre- and post-intervention measurements of body weight, height, and mid-upper arm circumference (MUAC), yielded significance values greater than 0.05 in the Shapiro–Wilk test. These results indicate that the data were normally distributed. Consequently, parametric statistical analysis using the paired t-test was appropriate for evaluating differences before and after the intervention.

Table 5. Paired t-test Analysis (n=30)

Variable	Mean ± SD (Pre)	Mean ± SD (Post)	Mean Difference ± SD	95% CI	p-value
Body Weight (kg)	10.15 ± 1.20	10.85 ± 1.25	-0.70 ± 0.45	-0.88 to -0.52	0.001
Height (cm)	81.50 ± 2.80	82.90 ± 2.85	-1.40 ± 0.90	-1.74 to -1.06	0.000
MUAC (cm)	14.80 ± 1.10	15.90 ± 1.15	-1.10 ± 0.80	-1.40 to -0.80	0.002

Paired t-test analysis revealed significant differences in all anthropometric measurements before and after the intervention. Mean body weight increased from 10.15 ± 1.20 kg to 10.85 ± 1.25 kg ($p = 0.001$). Mean height increased from 81.50 ± 2.80 cm to 82.90 ± 2.85 cm ($p < 0.001$). Mean mid-upper arm circumference (MUAC) improved from 14.80 ± 1.10 cm to 15.90 ± 1.15 cm ($p = 0.002$). These findings suggest that animal-based complementary feeding significantly enhances anthropometric outcomes among stunted toddlers.

DISCUSSION

The toddlers' ages ranged from 2 years to 3 years and 7 months. The most common age groups were 2 years 3 months and 2 years 7 months, each accounting for 6 children (20.0%). By gender, the majority of respondents were female, totaling 17 children (56.7%), while 13 were male (43.3%). Regarding parental education, most parents had completed junior high school (43.3%), followed by senior high school (33.3%), college education (13.3%), and elementary school (10.0%). Regarding parental income, the majority of respondents' families (66.7%) earned below the Regional Minimum Wage (UMR), while 33.3% earned at or above the UMR. (12) research highlights that 77% of the 30 toddlers in her study were in a stunted condition, as evidenced by anthropometric measurements (height-for-age). This demonstrates a significant prevalence of stunting within the studied population.

This finding aligns with research (13), in which most respondents were male, with 8 children categorized as short and 2 as very short. These figures are considerably higher than those for female children, among whom 7 were categorized as short and none as very short. Overall, girls tend to experience stunting less often than boys, especially during infancy and childhood. This is supported by the fact that in many developing countries, including Indonesia, female infants have a higher survival rate than male infants. Additionally, girls enter puberty two years earlier than boys. Collectively, these findings suggest that male children are more susceptible to stunting and/or being underweight compared to female children (13).

Therefore, this level of parental education is assumed to fall short of the basic education standard. Parental education is a crucial factor influencing a family's nutritional status. Parents with higher levels of education tend to better understand and implement healthy lifestyles, including nutritious food intake. This positive attitude is often reflected in the family's healthy eating habits. The mother's role is particularly crucial in a child's health and growth. Mothers with higher levels of education tend to be more effective at meeting their children's nutritional needs. Good maternal education is expected to encourage the adoption of positive attitudes toward family eating patterns, which in turn helps meet the family's overall nutritional requirements. Furthermore, a mother's education level also affects their ability to comprehend and absorb information related to child nutrition and health (14).

This finding aligns with the study by Wahyuni, which also showed a higher prevalence of stunting in households with incomes below the UMR, specifically 67 respondents (35.8%) in the stunted group, compared to only 45 individuals (22%) with incomes above the UMR. It's clear that increased income boosts the ability to purchase higher-quality and greater quantities of food. Conversely, a decrease in income reduces purchasing power for high-quality, sufficient food, which can directly affect nutritional status (15).

In conclusion, the findings on respondent characteristics align with Apriyani's research. This journal confirms that factors associated with stunting in children include: boys having a four times higher risk of stunting compared to girls , inappropriate feeding patterns at 6-8 months being a dominant factor , and untimely or low-quality complementary feeding (MP-ASI). Additionally, low household socioeconomic conditions and low maternal education levels (as mothers with higher education tend to better understand child nutrition and health) also contribute to the incidence of stunting (16). A mother must know which foods to give her child to meet their nutritional needs. Nutritional fulfillment can be achieved through local foods , just as protein in food is very important. Protein deficiency can inhibit the growth of tissues and organs, ultimately affecting a child's body weight. If the body lacks energy from carbohydrates and fats, protein will be used as an energy source, which should ideally be used for building the body (17).

The paired t-test analysis showed significant differences in all anthropometric measurements before and after the intervention. Mean body weight increased from 10.15 ± 1.20 kg to 10.85 ± 1.25 kg, with a statistically significant difference ($p = 0.001$). Similarly, mean height increased from 81.50 ± 2.80 cm to 82.90 ± 2.85 cm ($p < 0.001$). The mean mid-upper arm circumference (MUAC) also showed a significant improvement, increasing from 14.80 ± 1.10 cm to 15.90 ± 1.15 cm ($p = 0.002$). These results indicate that animal-based complementary feeding significantly improves anthropometric outcomes among stunted toddlers.. In line with the journal article by Ayu, the provision of animal protein-fortified supplementary feeding had a positive effect on the physical growth of stunted children. The research conducted by (19) implicitly asserts that animal protein is a primary source of essential amino acids (EAAs), which are crucial for children's growth and development. The journal references studies indicating that stunted children have lower serum amino acid levels compared to non-stunted children. Essential amino acids, such as lysine, leucine, and tryptophan, are vital for physical growth and cognitive development.

Consequently, adequate protein intake supports overall child growth and development, making it a critical component in addressing stunting. MP-ASI should meet several criteria: it must have high energy and protein content, be nutrient-dense, have a soft texture, offer good supplementation value, contain sufficient vitamins and minerals, and be easily digestible by the infant. It is recommended to include carbohydrate sources, protein (especially animal-based), fruits/vegetables, and fats (MP-ASI 4 quadrants). Animal proteins, such as meat, fish, eggs, and dairy products, are crucial for nutrients like protein, iron, zinc, calcium, selenium, potassium, vitamin B12, and vitamin A. Fruits and vegetables provide essential vitamins A and C, folic acid, and fiber. Grains and legumes meet micronutrient needs, providing protein, fats, fiber, B vitamins, and minerals such as magnesium, iron, zinc, calcium, and potassium (20). The problem of stunting in toddlers is related to low protein intake in daily food consumption (21).

Physical development encompasses body and brain growth, as well as changes and stability in sensory, motor, and health-related capabilities in children. This includes increases in height and weight, brain development, responsiveness to stimuli, and movement skills, all of which collectively influence a child's learning activities and overall personality. Anthropometry is a crucial healthcare technique for diagnosing and intervening in nutritional status, due to its high sensitivity in assessing a wide spectrum of nutritional conditions (23). In line with research (24), protein is abundant in local foods, such as livestock products (free-range chicken meat and eggs, purebred chicken meat and eggs, cow/goat milk, and rabbit meat). These are vital in combating stunting in children. By optimizing nutrient and protein content through appropriate recipe development and enhancing mothers' ability to process them, we can produce high-quality complementary feeding (MP-ASI), ensuring optimal nutrition and better child growth and development.

Protein is vital for children as it plays a crucial role in building new tissues and maintaining normal bodily functions. An individual's protein requirement is measured as the minimum amount

needed to maintain nitrogen balance (for maintenance), plus the additional amount required for new tissue growth. The World Health Organization (WHO), Food and Agriculture Organization (FAO), and United Nations University (UNU) estimate that infants and children need approximately 0.66 grams of protein per kilogram of body weight daily for maintenance, along with age-specific requirements for growth. This growth requirement gradually decreases as children age due to a slower growth rate. In addition to being rich in essential amino acids, animal protein is also a significant source of vital micronutrients such as iron, vitamin B12, choline, and calcium. These micronutrients are essential for optimal growth in children. Therefore, adequate protein intake, especially from animal sources, can effectively help address stunting in children.

This study faced several limitations, including a small sample size of only 9 stunted toddlers, which restricts the generalizability of its findings to a broader population. Additionally, the intervention duration was relatively short, lasting only 30 days, which may not be sufficient to observe significant long-term changes in anthropometric status or address all contributing factors to stunting. The study concluded that providing a combined therapy of processed animal protein in complementary feeding (MP-ASI) is effective in improving the growth of stunted children, as indicated by anthropometric values (body weight, height, and mid-upper arm circumference). This finding aligns with other research suggesting that animal protein is a primary source of essential amino acids crucial for child growth and development. Consequently, adequate protein intake, especially from animal sources, is deemed a vital component in stunting management.

CONCLUSION

Several policy implications emerge from these findings. First, local governments and health personnel should prioritize nutritional interventions by providing and promoting diverse animal protein intake for toddlers, particularly those identified as stunted. Second, child nutrition education for parents should be enhanced, with a focus on the benefits of animal protein and its preparation for complementary feeding (MP-ASI), given the significant influence of maternal and parental education on child nutrition. Third, policies should aim to increase low-income families' access to high-quality animal protein sources, such as through food subsidy programs, since many parents earn below the Regional Minimum Wage (UMR), which limits their purchasing power. Finally, health centers (Puskesmas and Posyandu) should play a central role in implementing these policies by providing animal protein-based supplementary feeding and ongoing nutritional counseling.

ACKNOWLEDGEMENT

We express our sincere gratitude to the Ministry of Education, Culture, Research, Technology, and Higher Education (Kemendikbud Ristek Dikti) and the Research and Community Service Institute of STIKES Panti Kosala.

AUTHOR'S CONTRIBUTION STATEMENT

W: served as the corresponding author, responsible for the overall project direction, research design formulation, supervision of data collection and analysis, and drafting the initial manuscript. W: also held primary accountability for data integrity and accuracy and contributed significantly to the conceptualization phase, methodology development, and data acquisition. W: was also actively involved in interpreting results and editing the manuscript draft. BK: played a crucial role in statistical data analysis, visualization of results, and the writing of the methodology and results sections. W: also assisted with the comprehensive literature review. BK: contributed to hypothesis formulation, field data collection, and the drafting of the discussion section. W, BK: also participated in data validation and the final manuscript review.

CONFLICT OF INTEREST
The author (s) declares that there is no conflict of interest.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS
The authors acknowledge the use of ChatGPT to support language improvement, improve clarity, and improve the overall readability and structure of the manuscript.

FUNDING
None.

DATA AVAILABILITY
The dataset generated and analyzed during the current study is available from the corresponding author upon request.

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