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Study of the importance of protein needs for catch-up growth in Indonesian stunted children: a narrative review

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Abstract

Stunting is a chronic nutritional deficiency due to various adverse cross-sectoral environmental conditions, including food intake. This influences the linear growth and development of children's brains and their cognitive function. Providing interventions to meet stunted children's protein needs tends to prevent the further abnormal development of cognitive functions. High-protein foods are supplied from various edible local commodities in Indonesia. Therefore, this study aims to demonstrate the importance of feeding stunted children with high-protein diets and provide insight that local food ingredients in the country have growth-promoting potential. Through Google Scholar, PubMed, Science Direct, and Nature, 107 articles were obtained with keywords related to stunting, such as protein intake, catch-up growth + stunting, and adverse effect + catch-up growth. The preferred citations randomized-controlled trials and systematic reviews relevant to the study question were compiled using Mendeley version 1.19.8. Based on the literature review results, stunting is hereditary and affects the quality of generations. The adequacy of protein needs is closely related to growth and development, hence, foods containing a high amount of the nutrient facilitate catch-up growth in stunted children. This conclusion is expected to provide information to policymakers and health agencies in the country concerning the education related to high nutritional local food, which can be reached by the community. Interventions with high-protein-containing local foods ought to be tailored to dietary needs and accompanied by monitoring for the presence or absence of unreasonable weight gain to prevent overweight or obesity.

Keywords

Stunting, protein, catch-up growth, amino acids, local food

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Introduction

In the National Medium-Term Development Plan (Rencana Pembangunan Jangka Menengah Nasional/ RPJMN) 2020–2024, stunting is among the nutritional problems highlighted in the Sustainable Development Goals to achieve staying without hunger.[1] Globally, approximately 22% or around 149.2 million in 2020 experienced stunting,[2] a linear growth failure.[3] The condition is characterized by an abnormality in a person's height based on age and gender and indicates chronic malnutrition occurrence.[4–6] In the meantime, the proportion was 14.9% in Southeast Asia or the second largest after South Asia.[2] Indonesia Basic Health Research data showed that the prevalence of children with a severely stunted nutritional status was 11.5% in 2018. Furthermore, the prevalence of children with a moderately stunted nutritional status was 19.3% in 2018. The percentage of these two statuses was 30.8 % in 2018.[7] Although the prevalence of stunting has decreased, the proportion in the national level demonstrates it as a nutritional problem that needs to be addressed.

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According to the World Health Organization (WHO), stunting is identified by low height-for-age due to chronic or recurrent undernutrition and also described as a form of both conditions. These incidents are generally related to poverty, poor maternal health and nutritional adequacy, high illness frequency, and poor early life parenting.[8] Stunted children are associated with delayed motor development, impaired executive brain function, and poor school performance.[9] Furthermore, it is related to an increase in morbidity, mortality, and adults' risk of chronic diseases as well as a decrease in physical growth potential and neuronal development,[4,5] which affects the quality of future generations.

Amino acids, classified as essential and non-essential, are organic substances containing carboxyl and amino groups plus specific side chains.[10] The essential types come from proteins participating in the growth process.[11] Moreover, their carbon skeleton cannot be completely or effectively synthesized de novo by the body and must be obtained from food intake to achieve optimal adequacy of needs. Other criteria for classifying essential or conditionally essential amino acids are functional needs such as reproduction and disease prevention. The non-essential types are synthesized de novo in sufficient amounts by the body.[10]

Several studies identified that certain serum amino acid levels in stunted children are characteristically lower than those in non-stunted children.[12,13] One of the factors enhancing children's linear growth is the adequacy of energy intake and high-quality protein.[14] Amino acids, specifically the essential types such as lysine, leucine, and tryptophan, are required for growth and cognitive development.[13,15,16] However, these protein needs are not usually met due to low household socioeconomic conditions or poverty.[17]

The improvement of nutritional status in stunted children is possible. This is achieved through several factors including maternal factors via maternal education level and height, economic status, socio-culture, nutritional supplementation, and community-based intervention.[18] The first 1000 days of children is a golden period to prevent disturbances in metabolic programming because their development's degree of plasticity is high. During this period, exposure to adverse environments affects growth acceleration, cell replication, differentiation, and functional development of organ systems.[19]

Georgiadis et al.[20] stated that growth after childhood still leads to improvements in cognitive development. They analyzed cohort data on the stunting incidence and cognitive function in children aged 1, 5, 8, and 12 years in Peru. Based on the results, affected children who recovered in Peru after 5 years had higher achievement scores at 8 years than their remaining stunted counterparts. This indicated that growth after 5 years and early adolescence is still responsive to environmental changes, and a quicker process rate within the mentioned period is associated with several factors.

Improved nutritional status in children is related to the type of food consumed, primarily related to eating patterns based on certain ethnicities due to differences in food choices. In Indonesia, consumption of animal protein sources tends to be low.[18] Therefore, supplementary food rich in protein content needs to be consumed to meet nutritional needs and overcome stunting. A previous study proved that high-protein foods provision help the linear growth of stunted children.[21] Some local sources of essential amino acids easily found in Indonesia include rice, sweet potatoes, cassava, tuna, mackerel, tempeh, red beans, pumpkin, carrots, and eggs.[22,23] Giving a high-quality, legume-based protein-fortified food product for a month was also stated to support height increment significantly.[21] Therefore, this literature study aims to review stunting impacts and the importance of meeting protein needs based on the type and processing of food ingredients to treat affected children.

Method

We collected research literature published after 2011, which studied stunting children, protein, and its influence and relationship to catch-up growth of stunted children. We conducted our literature research using Google Scholar, PubMed, Science Direct, and Nature. A total of 107 articles were obtained with keywords related to stunting, such as amino acid, local food, protein food source, protein intake, catch-up growth, and adverse effect. The preferred citations of randomized-controlled trials and systematic reviews relevant to the study question were compiled using Mendeley version 1.19.8.

Result

Stunting

The *z*-scores of length-for-age in children between 1 and 2 years or height-for-age in 3–5 years below −3 SDs from the Indonesian Minister of Health Decree, which also refers to WHO, indicate a severely stunted nutritional status while stunted is −3 SD to less than −2 SD. Threshold categories of children's nutritional status based on the index of the Indonesian Minister of Health Decree concerning Anthropometric Standards for Assessment of Children's Nutritional Status in 2020 are presented in Table 1.[24]

Pathophysiology of stunting. Stunting occurs once children cannot reach their linear growth potential. However, in the process, the growth rate of stunted individuals does not decline suddenly. At a particular period, children with an inadequate intake of both macronutrients and micronutrients experience a phase of growth faltering, which often begins in the uterus and continues into the first 2 years of life after birth. Hence, the presence of stunting and significant decline in growth from the normal range needs to be considered.[5,25,26] Human growth and development process is a complex system based on the influence of genetic blueprints and environmental conditions. In the conception period, environmental conditions influence the genetic blueprint that affects children's growth and development potential. This depends on several factors such as the period

Table 1. Anthropometric standards for assessment of children's nutritional status.

Index	Nutritional status category	Threshold (Z-score)
Body length or height-for-age (L/HAZ) for children aged 0–5 years	Severely stunted	<−3 SD
	Moderately stunted	−3 SD to <−2 SD
	Normal	−2 SD to +3 SD
	Tall	>+3 SD

Source: The Indonesian Minister of Health Regulation Number 2 of 2020 concerning Children Anthropometry Standards (*Peraturan Kementrian Kesehatan Republik Indonesia*).

and strength of influence, exposure duration, occurrence frequency, age, and children's gender.[4]

Low levels of essential amino acids are one of the characteristics commonly found in stunted children. Previous studies showed that certain serum amino acid levels in stunted children are lower than in non-stunted.[12,13] According to Semba et al.[13] cohort study, the levels of nine essential and several non-essential amino acids such as asparagine, glutamate, and serine were significantly lower in stunted children than in the non-stunted. This was due to inadequate amino acid intake in children with a high risk of stunting.[13]

In addition to the intake of food sources rich in amino acids, dysbiosis of the gastrointestinal microbiota is known to be associated with malnutrition and decreased plasma levels of essential amino acids.[27,28] Surono et al.[27] research results showed differences in the gastrointestinal microbiota between stunted children and children with normal nutritional status in Indonesia. Prevotella 9, which may contribute to energy extraction from the diet through the formation of short-chain fatty acids, is found in many children in Indonesia and is significantly lower in stunted children. In addition, Enterobacteriaceae, the Proteobacteria phylum often associated with human pathogenicity, also increases due to disturbances of digestion, absorption, or local intestinal inflammation.[29]

This study's results align with the research of Kumar et al., which showed that the index of a diversity of the gastrointestinal microbiota was lower in countries with a higher prevalence of stunting. Metabolic functional categories based on the gastrointestinal microbiota showed that healthy children dominated lysine biosynthesis, phenylalanine, glycerophospholipid, redox, and beta-alanine metabolism in Sweden compared to other countries studied (Malawi and Bangladesh). The highest number of reactions is found in the functional category of amino acid metabolism, which covers 19%–23% of the total reactions in the Community Metabolic Models. At the individual level, the essential amino acids lysine and threonine levels and the conditional amino acid arginine were significantly lower in stunted children compared to the healthy group.[28]

Abnormal amino acid metabolism disrupts the body's homeostasis, inhibits growth and development, and even causes death. Moreover, the functions of amino acids include participation in gene expression, hormone synthesis and secretion, nutrient metabolism, protection against oxidation, immunity, reproduction, growth, and children development.[10]

Stunting risk factor. According to Uwiringiyamana et al., the low coverage of exclusive breastfeeding and complementary feeding (MP-ASI) quality played a role in stunting in Rwanda.[30] The results showed that energy intake predicts body length in children aged 12 to 17 months. Optimal nutrition during complementary feeding, exclusive breastfeeding, and deworming drugs was concluded to reduce stunting risk in the northern province of Rwanda.[30] Ismawati et al. conducted a study related to nutritional intake and causative factors of stunting in toddlers in Lamongan, Indonesia. Based on the results, the average nutritional intake of stunting children, including energy, protein, calcium, and phosphorus, is below the recommended daily allowance. This low value occurred due to inadequate nutritional intake, specifically total energy, directly related to children's physical growth. In addition, infectious diseases and parental characteristics, which include occupation, income, and knowledge, are causative factors for stunting in individuals under 5 years of age in Lamongan.[31]

In Indonesia, the study by Titaley et al. on stunting prevalence factors showed that economic conditions' index is related to incidence recorded at the household level. Low economic conditions affected purchasing power, access to quality food, and adequate health services.[17] The number of children aged 1–3 years and other family members significantly affects stunting occurrence. This is because a large number influences the accessibility and availability of poor food, thereby causing an impossibility to achieve nutritional adequacy and good health status.[17]

Research by Khusun et al. in 2022 in Indonesia shows that socioeconomic level is related to the diversity and adequacy of vegetable and animal protein consumption. The results showed that lower socioeconomic levels had lower protein diversity. The low protein diversity reflects the low intake of essential amino acids such as lysine, leucine, and valine.[32] The results of another particular study show that the total calculation of the frequency of consumption of animal protein in Indonesia is 34%. One factor influencing the consumption level of red meat and poultry is high social and economic status, where the social gradient in Indonesia is observed to be stronger.[33]

Indonesian high-protein local food

Indonesia is a country rich in varieties of edible food sources.[34] However, 46.1% of Indonesian children aged 6–23 months still need to meet the minimum dietary diversity.[35] People's economic level influences protein intake and diversity in Indonesia. Adequacy of protein intake and access to animal protein sources will increase along with economic status.[32,33] However, protein sources with the right type and amount can help meet protein needs. Therefore, it is essential for the people of Indonesia to know that local high-protein food ingredients are available and affordable to help meet their daily protein needs regardless of their economic status.

Animal protein. Essential amino acids are more completely contained in proteins from animals than plants. Plant protein sources generally contain lower protein completeness due to lower digestibility and lack of specific sources of essential amino acids compared to animal protein. Some examples of dietary sources of animal protein are eggs, meat, chicken, fish, and dairy.[36] Research results by Khusun et al. show that 35.4% of protein sources consumed by Indonesian people come from animal protein sources. Specifically, 12% comes from meat and poultry, 12.8% from eggs and milk, and 9.8% from fish.[32]

Proteins from animals than plants alone have better bioavailability and biological value,[23] which is due to anti-nutrients that are more commonly found in plant-based proteins. One of these is the tannins in cereals and legumes that affect protein digestion and cause a decrease in essential amino acids by forming a tannin-protein complex.[37] Besides, other naturally occurring anti-nutrient substances are trypsin inhibitors and hemagglutinins in legumes, and phytates in cereals and oilseed.[38] Tannins, phytates, trypsin inhibitors, and protease inhibitors are found in soya beans. Polyphenols and phytic acid are anti-nutrient substances in rice.[37]

Although protein from animal protein sources has higher bioavailability than plant protein, high consumption of animal protein is positively associated with mortality from cardiovascular disease, especially in individuals with at least one risk factor in their lifestyle. In addition, a high intake of animal protein is more at risk of causing obesity compared to vegetable protein. Substitution of animal protein with vegetable protein, mainly processed red meat, is associated with lower mortality.[39,40] On the other hand, research results show that reducing the consumption of animal protein sources can minimize greenhouse gas emissions and water consumption. As a solution, adopting an omnivorous diet that complies with nutritional guidelines by reducing calorie and fat intake to the recommended level or a vegan diet where more vegetable protein sources are consumed is recommended.[41–43]

Plant protein

Examples of plant-based protein include soy and mung beans, grains and their products, legumes, seeds, and vegetables.[44,45] Other sources which are the country's staple food include rice, cassava, and potatoes.[23,44] The results of the research by Khusun et al.[33] show that 65.4% of the vegetable protein consumed by Indonesian people mostly comes from cereals, namely rice and beans.

In Indonesia, tempeh and tofu are plant-based proteins consumed daily. Tempeh is a traditional Indonesian food made from soybeans and fermented with Rhizopus spp. The fermentation produces white fibers and is generally processed by frying[46] or cooking with other vegetables. The fermentation process in tempeh is known to improve the quality of its nutritional content, including reducing the content of anti-nutrients, increasing protein digestibility, and increasing its amino acid content.[47–50]

Local food processing

Heating or alkaline processes also tend to form anti-nutrients. Protein sources in food processing are generally heated, treated with oxidizing agents, alkaline organic solvents, and acids for certain purposes such as sterilization and improvement of taste and texture. Such processing generates Maillard components or sulfur amino acid oxidation and cross-links formation reducing amino acid content and protein digestibility.[38]

Protein source types and their processing must be considered to obtain adequate protein intake. Based on the source, the proportion of animal and plant-based protein consumption ought to be assessed. Food sources processing is examined to maintain the amino acid content and protein digestibility. Means of overcoming anti-nutrients in foodstuffs are milling, questioning, germination, autoclave and microwave treatment, and fermentation, one of the best methods often used. The fermentation process in cereals by lactic acid bacteria increases essential amino acids such as lysine, methionine, and tryptophan through proteolysis and metabolic synthesis.[37]

Indonesian agricultural commodities such as mung beans and milk are sources of protein used as structural components in high-protein food formulations. In 2020, Kusumah et al. conducted a study on manufacturing protein isolates from red and mung beans. Based on the results, both isolated products had the highest essential amino acids, such as lysine and leucine. The lysine contents of powdered protein isolate from red and mung beans were 15,929.89 mg/kg and 14,916.14 mg/kg, respectively. The second-highest amino acid level was leucine, where the red and mung bean isolate content was 12,385.81 mg/kg and 12,694.86 mg/kg, respectively.[15] The isolation of mung bean protein is beneficial in improving stunted children's nutritional status due to its excellent digestibility.

Catch-up growth in stunted children

Boersma and Wit describe catch-up as 'height velocity above the statistical limits of normality for age and/or maturity during a defined time, following a transient period of growth inhibition'.[51–53] Growth and development is expected to improve the child's growth curve towards pre-retardation. Four criteria need to be met to indicate the presence of catch-up growth in height. First is conditions inhibiting growth and second is a period of decreasing linear growth velocity. The third is alleviating conditions that inhibit growth and the fourth is accelerating a higher than normal growth.[53]

Potential catch-up growth in stunting children. The review article by Leroy et al. showed the possibility for undernourished children to catch up, specifically in terms of stunting. A supportive environment is required to achieve a dramatic catch-up. Although catch-up is possible, there are some irreversible effects of undernutrition.[53]

Linear catch-up growth is possible, but it is usually not complete in some cases, particularly in the brain and neurocognitive development aspects. A stimulus such as nutritional intake not obtained in a critical period permanently impacts the child's development. Maternal nutritional status during pregnancy is also known to impact DNA methylation in the offspring permanently.[53]

A recent review concluded that growth spurts in the brain and neurocognitive function were not achieved totally. Also, the prospective cohort study by Crookston et al., (2010) in 1674 children showed that cognitive function in children who had recovered from stunting was not significantly different compared to their non-stunted counterparts.[52]

Koshy et al. conducted a community-based birth cohort study on 203 stunted toddlers in India. In contrast to Crookston et al., the results showed that among 46.31% or 94/203 of children who experienced stunting at 2 years, 39.36% achieved catch-up growth at 5 years, while 38.30% at 9 years and 10% did not recover. Children who were stunted at 2, 5, and 9 years had significantly lower verbal abilities and total intelligence quotient of 4.6 points than the non-stunted. However, children who achieve catch-up growth at 2 years have higher cognition than those who persistently experienced stunting during childhood.[36]

An experience of milder stunting incidence at the beginning of measurement is directly proportional to the tendency of catching up with growth.[54] This indicates that although restoring cognitive function may not be achieved completely, early recovery in stunted children prevents further declines in cognitive scores than the persistently stunted individuals.

Factors affecting catch-up growth. As described in the previous point, namely early stunting detection, ages attained during stunting and recovery affect the extent of achieving catch-up growth.[54,36] Based on Crookston et al. regarding recovery from stunting and its impact on cognitive function, factors related to growth catch-up are children's age at the second assessment, mother's height, and grandparents living at home.[52] Id et al. reported that the timeliness of child immunization, maternal parity, and household socioeconomic status were also important factors related to stunting recovery time in the first 5 years of life. Post-stunting linear growth is strongly influenced by the children's disease status and age at first stunting experience, parity, and maternal age.[55] Generally, a dramatic increase in catch-up growth is supported by food intake, water hygiene, sanitation, and opportunities in learning and receiving responsive assistance in stable household conditions.[53]

The control of environmental or external factors needs to be pursued to achieve catch-up. Community-based intervention is one way to increase the knowledge of mothers or families on nutrition, child behavior, and parenting that play an important role in changing children's nutritional status. Increased knowledge is expected to promote awareness and change in behavior such as eating patterns to augment protein and energy intake as well as child growth.[18] In addition, community-based interventions tend to increase knowledge to prevent stunting in future generations.

Protein needs in stunted children

Protein is a macronutrient that plays an important role in children's growth. Its intake is a factor affecting height, hence, individuals with low intake have a higher risk of stunting.[56] Based on the results, 30.6% of children with protein intake below the recommended standard are stunted. Those with lower protein intake are four times more likely to experience stunting than children with adequate intake. The higher risk is because protein intake participates in stimulating insulin on IGF-1 since serum tryptophan and IGF-1 levels are positively associated with linear growth.[57]

Similarly, essential amino acids from protein function in the growth process. This nutrient is needed in childhood because it acts as a substance that repairs damaged body tissues, builders, regulators, serum formation, hemoglobin, enzymes, hormones, antibodies, and other important components while helping body regulation.[11]

Protein for catch-up growth. Stunting is caused by experience of chronic protein-energy deficiency. Therefore during recovery, protein needs of stunted and normal children for the growth process are also different. Several previous studies showed that adding high-protein foods at least improves linear growth biomarkers in children.

According to Varkey et al., giving protein-fortified nuts-based food products to stunted children aged 6–10 years for a month affected biomarkers related to linear growth and significantly supports height growth.[21] Lower abundance of *Faecalibacterium prausnitzii* and increases in the three operational taxonomic units of *Bacteriodetes* and Firmicutes were significantly associated with increased height in all children after the intervention.[21] Besides changes in the microbiome profile, IGF-1 levels were positively associated with changes in height, while serine and ornithine were negatively correlated.[21] The median height gain during the intervention month was 0.9 (0.5–1.2) cm, which exceeded standard height gain. Based on the Indonesian Minister of Health regulation, the standard height gain per month for ages 6–10 years is 0.1 cm.[24] Increases in height and weight were positively correlated with plasma levels of IGF-1, and leptin, as well as changes in serum metabolites, which is in line with Bartz et al. results. Based on the study, increased serum levels of IGF-1, leptin, and branched-chain amino acids were significantly associated with weight gain according to height as part of recovering malnourished children after 2 weeks of nutritional rehabilitation with ready-to-use

Table 2. Children's amino acid needs.

Age (years)	Protein requirements (g/kg per day) for		His	Ile	Leu	Lys	SAA	AAA	Thr	Trp	Val
	Maintenance	Growth	Amino acid needs (mg/kg per day)								
0.5	0.66	0.46	22	36	73	64	31	59	34	9.5	49
1–2	0.66	0.2	15	27	54	45	22	40	23	6.4	36
3–10	0.66	0.07	12	23	44	35	18	30	18	4.8	29
11–14	0.66	0.07	12	22	44	35	17	30	18	4.8	29
15–18	0.66	0.04	11	21	42	33	16	28	17	4.5	28
>18	0.66	0	10	20	39	30	15	25	15	4	26

Source: Protein and amino acid requirements in human nutrition: Report of a joint FAO/WHO/UNU expert consultation.

therapeutic food.[21,58] These studies indicated that children's height growth is sensitive to dietary protein intake, specifically in the form of amino acids. High-protein supplementary feeding is associated with linear growth acceleration and tends to influence its biomarkers. Further study related to the type of supplementary protein food source, protein content amount, and the duration of administration is possibly needed to determine the most appropriate duration of intervention for normalizing stunted children's nutritional status.

Several previous studies proved protein supplementation in stunted children to facilitate the catch-up process in linear growth and development. The result showed that lysine supplementation from children's diet in sub-adolescent orphanages for 5 months increased growth and bone density compared to the control group. The total intake of lysine given was more than five times their requirement. However, changes in bone growth and density tend to occur due to lysine's pharmacological effect, which increases calcium absorption.[59,60]

There is evidence that improving maize protein quality promotes height growth due to its low levels of lysine and tryptophan. Therefore, maize varieties with good agronomic properties were developed by selective breeding with higher levels of lysine and tryptophan. Although one of the quality protein maize (QPM) varieties has entire protein content, it increased the levels of lysine, tryptophan, amino acids sulfide, and threonine by 50%, 75%, 90%, and 40%, respectively. This showed that adequate and QPM content accelerate linear growth in children and recovery from malnutrition.[60,61]

The following are the amino acid requirements according to Report of a Joint WHO/FAO/UNU Expert Consultation 2007 (Table 2).[62,63]

Potential adverse effects in catch-up growth. Some studies showed that catch-up growth has an adverse effect in the long term. Nutrients as a major contributor, specifically in the early life growth rate, greatly affect long-term health. In the early stages of life, catch-up growth has been identified as a risk factor for abnormal weight gain. Rapider weight gain within the first 6 weeks of life increases non-communicable diseases risk in the future and obesity at 6–8 years old.[64,65]

High-protein intake during the first 2 years of age has been associated with the incidence of obesity in the future, especially from animal protein sources.[40,66] In Indonesia alone, the prevalence of obesity in infants aged less than 5 years in 2018 was 11.8%.[67,68] Therefore, children's weight monitoring in the linear growth process is important for preventing overweight or obesity.

Additionally, the promotion of quality and nutritious diet as well as a balanced combination of protein sources needs to be performed. Assurance of the food provided is required to avoid increasing the risk of an unhealthy diet that tends to promote abnormal weight gain indirectly. Interventions, programs, and policies ought to be designed together to reduce the risk of undernutrition and overweight or obesity.[65]

The limitation of this study is that previously reported results related to catch-up growth, influencing factors, and interventions to overcome stunting have not been entirely from Indonesia. Although local Indonesian food has been discussed, the articles reviewed are not specific to certain parts of this country with various geographical, ethnic, and cultural backgrounds. This diversity allows the problems and solutions of stunting to vary in each province.

Conclusion

Stunted children experience disturbances in growth and development in the short and long term, some of which are irreversible. Protein plays a vital role in individuals' growth and development. This is indicated by the amino acid levels of stunted children being lower than those of the non-stunted. Previous studies showed that the provision of protein promotes growth in stunting cases. Therefore, the processing of food with appropriate protein type and content, as well as its provision, is needed to restore growth and development in stunting. Combining food protein sources between plant and animal-based dietary sources needs to be considered to completely meet essential amino acids' needs.

Upcoming stunting alleviation programs need to improve the education related to high nutritional local food and which can be reached by the community. Interventions with high-protein-containing local foods ought to be tailored to dietary needs and accompanied by monitoring for the presence or absence of unreasonable weight gain to prevent overweight or obesity. Although some aspects are not completely recoverable, catch-up growth in stunted children must still be sought to reduce the long-term impact of malnutrition. Consideration of controllable environmental factors is required to support the recovery process, such as hygiene and sanitation plus knowledge related to nutrition.

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Author contributions

The authors confirm contribution to the article as follows: study conception and design: A. Endrinikapoulos, D. N. Afifah, R. Andoyo, and I. Hatimah; article collection: A.Endrinikapoulos, D. N. Afifah, M. Mexitalia, and N. Nuryanto; interpretation of results: A. Endrinikapoulos, D. N. Afifah, M. Mexitalia, R. Andoyo, I. Hatimah, and N. Nuryanto; draft article preparation: A. Endrinikapoulos, D. N. Afifah, M. Mexitalia, and N. Nuryanto. All authors contributed to the revision of the article, reviewed the result, and read and approved the final version.

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