nutrición clínica y Dietética Hospitalaria

Artículo Original

Nutr Clín Diet Hosp. 2024; 44(3):117-123
DOI: 10.12873/443mukhlas

Protein intake recommendation for stunted children: An-update review

Al MUKHLAS FIKRI[1], Widya ASTUTI[2], Vieta Annisa NURHIDAYATI[3], Fajria Saliha PUSPITA PRAMESWARI[2], Nazrul HADI ISMAIL[4]

1 Department of Nutrition, Faculty of Health Sciences, Universitas Singaperbangsa Karawang, Indonesia.
2 Nutrition Study Program, Faculty of Sport and Health Education, Universitas Pendidikan Indonesia, Bandung, Indonesia.
3 Management of Food Service and Nutrition Study Program, College of Vocational Studies, IPB University, Bogor, Indonesia.
4 Centre for Dietetics Studies, Faculty of Health Sciences, Universiti Teknologi MARA, Malaysia.

Recibido: 14/marzo/2024. Aceptado: 11/junio/2024.

ABSTRACT

Introduction: Childhood stunting remains a pervasive global health issue affecting millions of children, with significant repercussions on their physical and cognitive development.

Objective: This study aimed to collect information on dietary guidelines and protein recommendation specifically designed for stunted children.

Methods: A systematic review was performed using several databases, including Pubmed, Scopus, and Google Scholar. A literature search was conducted to collect studies on dietary guidelines (keywords: Dietary recommendation OR Dietary Guidelines AND Stunting OR Stunted OR Retarded Growth) and protein recommendation (keywords: protein AND catch-up growth AND stunting AND children OR infant) for stunted children. This review also included a narrative review for additional information.

Results: A total of 12 and 9 related articles were included in this systematic review on dietary guidelines and protein intake, respectively. This systematic review shows that protein intake stands out as a critical determinant in stunting, with low intake associated with growth faltering. However, guidelines specifically tailored to manage stunting remain scarce. Current evidence suggests protein's beneficial role in supporting linear growth, but excessive intake may contribute to obesity risk, highlighting the need for balanced recommendations.

Conclusion: This review synthesizes existing knowledge on protein's role in stunting management, emphasizing the importance of appropriate protein intake in promoting optimal growth while mitigating associated risks.

Keywords: dietary guidelines, protein requirements, retarded growth, systematic review, under-five children

INTRODUCTION

Childhood stunting remains a critical global health concern, posing significant challenges to the physical and cognitive development of millions of children worldwide. The World Health Organization (WHO) reported that 22.3% of all under-five children worldwide were stunted in 2022[1]. Stunting can be characterized by impaired linear growth and height-for-age deficits, reflecting chronic malnutrition during the early years of life. As the manifestation of childhood malnutrition, stunting can have profound and lasting consequences that extend beyond physical stature, including delayed cognitive development, reduced immune function, and increased risk of chronic diseases[2].

Stunting is caused by multifactor, but poor nutritional intake and frequent infection are the two crucial determinants[2,3]. Specifically, protein, as a fundamental macronutrient, plays a pivotal role in supporting various physiological processes crucial for growth and development. A study in Malawi showed a significant association between low animal protein intake and decreased height-for-age z-score in under five children[4]. A randomized controlled trial (RCT) comparing high and low

Correspondencia:
Al Mukhlas Fikri
mukhlas.fikri@fikes.unsika.ac.id

protein intake from complementary feeding revealed that length-for-age z-score increased significantly in high protein complementary feeding[5].

Despite current evidence showing the beneficial effect of protein on improving the linear growth of stunted children, information regarding protein intake guidelines for managing stunting is still limited. To the best of our knowledge, there are currently no specific guidelines on nutrition management for stunted children. The guidelines are mostly found for growth catch-up considering the rate of weight gain. WHO recommends a protein intake of 2.82 g/kg/day for optimal catch-up[6]. Moreover, the other recommendation demonstrates that the intake can reach 5.4 g/kg/day for supporting catch-up growth[7].

Considering relatively unclear recommendations for stunted children, some studies showed a risk of obesity after administering stunted or malnourished children with a high protein diet. A systematic review showed that high protein content in infant formula may increase the risk of obesity in later life[8]. A European Union CHOP study found that children's body mass index (BMI) and obesity risk were reduced (2.43 lower) by lower protein content in infant formula[9]. Due to the high velocity of growth after high-protein intervention, this may lead to increased IGF-1, lower β-oxidation, and excessive adipogenesis. Therefore, the objective of this study was to present current evidences assessing the role of protein in stunting management.

METHODS

A systematic review was performed to collect the present evidences on dietary guidelines and protein intake recommendation for stunted children. A literature search was performed across databases, including Pubmed, Scopus, and Google Scholar from February to May 2024, with no restrictions on publication dates. Keywords used to collect studies on current dietary guidelines for stunting were "Dietary recommendation" OR "Dietary Guidelines" AND "Stunting" OR "Stunted" OR "Retarded Growth". Moreover, keywords for studies on protein recommendation were "Protein" AND "Catch-Up Growth" AND "Stunting" AND "Children" OR "Infant". The inclusion criteria in the dietary guidelines or protein intake recommendation literature search were to evaluate or suggest dietary guidelines or protein intake specifically for under-five stunting recovery with no comorbidities. Any supplement was not considered to be included. All related studies were included with no restriction on the design of study. All literature searches were conducted with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. A manual literature search was also performed to ensure that the retrieved studies were complete.

RESULTS AND DISCUSSION

Protein Intake and Its Association with Stunting

Adequate protein intake is needed by all humans across their lifespans to ensure optimal growth and development. Protein can stimulate the release of the hormone which is responsible for cell proliferation and differentiation. Insulin-like Growth Factor-1 (IGF-1), also known as somatomedin, is one important hormone that is closely related to protein intake. IGF-1 consists of 70 amino acids with a molecular weight of 7,649 Daltons. IGF-1 is a hormone produced in the liver and regulated by the secretion of growth hormone (GH) from the anterior pituitary gland. In general, IGF-1 plays a role in stimulating cell growth, protein anabolism, and inhibiting apoptosis. Almost all cells in the human body are influenced by the actions of IGF-1, especially in muscles, cartilage, bones, liver, kidneys, nerves, skin, and lungs[10].

IGF-1 can promote bone growth and calcium absorption in the body. The study revealed that low IGF-1 levels in the body can increase the risk of bone fractures. Another study by Tang[5] stated that IGF-1 is a major supporting factor for bone growth, significantly influencing a person's linear growth. During the active growth period in children and adolescents, IGF-1 plays a role in the process of longitudinal bone growth. IGF-1 stimulates the epiphysis, which is the end of the long bone, to continue producing new bone cells, resulting in an increase in bone length. Therefore, children with low IGF levels are at a greater risk of experiencing stunting[11].

Lower protein intake has been identified as a significant contributor to delayed linear growth in children, exposing them to a higher risk of stunting than those with sufficient protein intake. This correlation is further emphasized by the finding that the average protein intake of stunted children is 13 grams lower compared to their normal-height counterparts[12]. Inadequate intake of essential amino acids limits the utilization of protein to support overall growth, especially linear growth. A study conducted in Malang, Indonesia, revealed that stunted children exhibited significantly lower intake of essential amino acids, such as histidine, isoleucine, and methionine, even when their overall protein intake was categorized as normal[13].

Current Dietary Guidelines for Stunted children

A total of 1065 articles were initially collected from the databases, while 108 articles were removed due to duplication. After reviewing title and abstract, 96 articles were included for further review. Among these, only 12 articles were included in this study. The rest were excluded for various reasons, including not discussing stunting recovery (63 articles), non-dietary recommendations (17 articles), including subjects over 5 years (3 articles), and being set in an emergency context (1 article) (Fig 1).

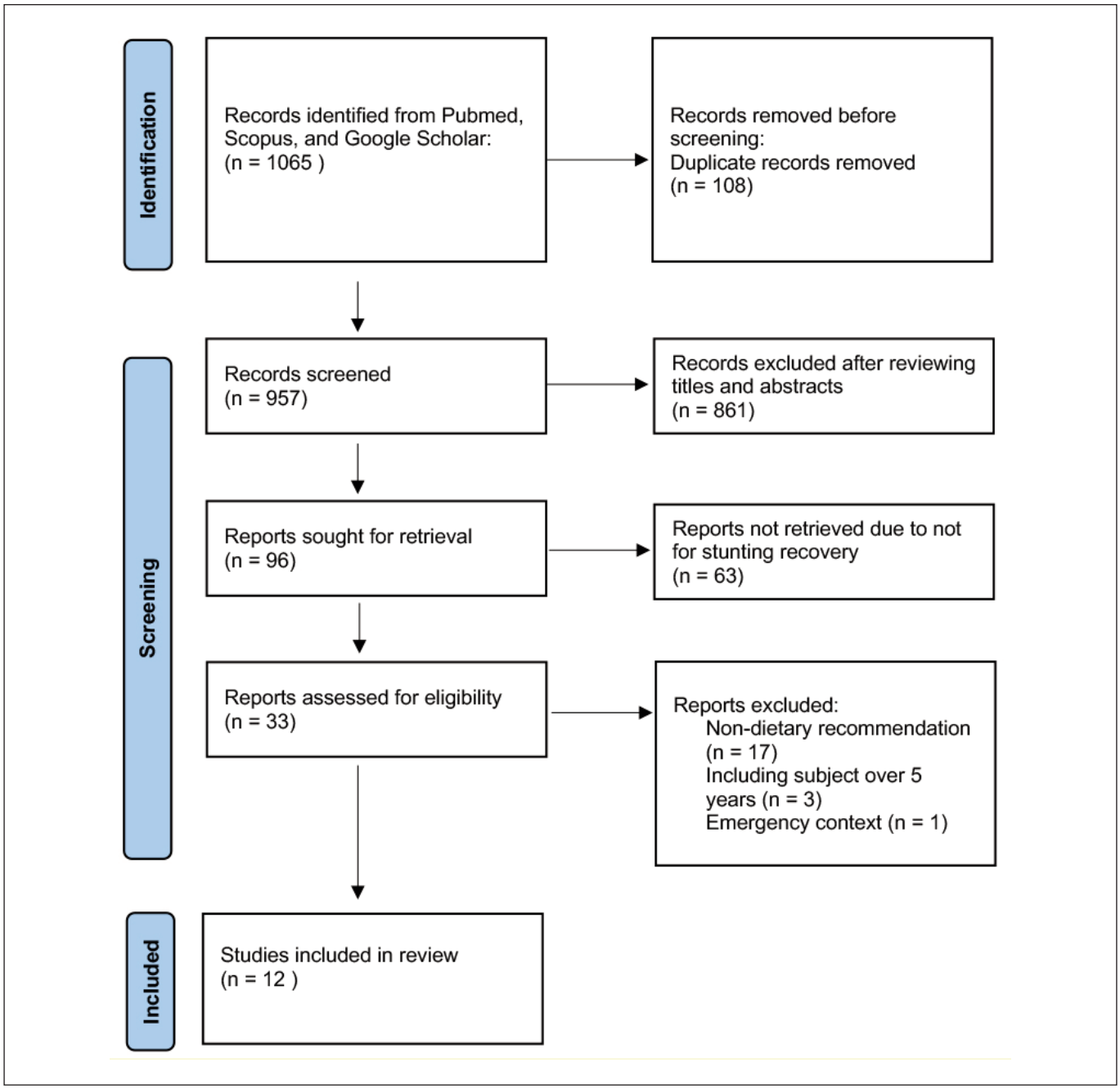

Figure 1. Prisma flow diagram for identifying study on dietary guidelines for stunted children

With the purpose of collecting data on the current dietary guidelines for stunted children, this study obtained 4 randomized controlled trials (RCTs), 3 systematic reviews with or without meta-analysis, 2 cross-sectional studies, and the rest were policy brief, guidelines document, and narrative review. The studies were originated from several countries, including Cambodia, Indonesia, Ecuador, Malawi, United States, and Chad. However, the included study did not discuss specifically dietary guidelines for stunted children. They partially suggested several points for dietary guidelines, including exclusive breastfeeding[14,15], consuming nutrient-rich and diverse diet[14,16], providing complementary food supplements[17], promoting the daily consumption of animal food sources[18], such as fish[19], egg[20], meat[5], and milks[21,22]. However, the other studies recommend to perform further study on fish[19], egg[23,24], and milk[25] due to lack of evidence. Moreover, one study showed that ready-to-use supplementary food (RUSF) for 4 months may be used to recover the height of stunted children[26] (Table 1).

In children with stunting, the determination of their nutrient requirements is adjusted with their height age rather than

Table 1. Characteristics of included studies on dietary guidelines for stunted children

No	Author	Country	Type of article	Results/ Dietary Recommendation
1	Tang et al.[5]	US	RCT of meat and dairy base complementary feeding for 7 months toward children aged 5 months	A complementary diet based on meat and dairy provides differing results in infant length. Meat has been showed to increase length-for-age Z-score, whereas dairy does not.
2	Arthur et al.[15]	-	Systematic review	Breastfeeding is important to help recover malnourished children
3	Penny[17]	-	Narrative review	Complementary food supplements may be used to catch-up growth. However, studies have demonstrated that complementary food supplements (peanut butter or beans with or without milk) showed beneficial effect in term of weight gain but not linear growth.
4	Asare et al.[18]	-	Systematic review and Meta-analysis	Animal-source foods are considered as a suitable supplementary food for improving the growth of 6 to 24 month children
4	Byrd et al.[19]	-	Systematic review	Promoting the consumption of fish could catch-up the growth, but more evidence is needed
6	Iannotti et al.[20]	Ecuador	Randomized controlled tiral (RCT) of consuming 1 egg per day for 6 months toward 6-9 months children	Egg could be introduced early to children for stunting reduction
7	Fikawati et al.[21]	Indonesia	A cross-sectional study involving 113 toddlers aged 3 years	Milk consumption could be considered as an important strategy to reduce stunting
8	Sjarif et al.[22]	Indonesia	A cross-sectional study with a total of 41 stunted (height-for-age z-score less than -2) and 131 normal under-five children	Growing up milk can be considered as part of a daily diet to protect children from stunting. However, several meat products, including sausage, nugget, and meatball, could not be considered as animal protein sources due to wide variations of nutrient content.
9	WHO[23]	-	Guidelines Document	Egg had no effect on overall linear growth
10	Stewart et al.[24]	Malawi	RCT of consuming 1 egg per day for 6 months toward 6-9 months children	Egg had no effect on overall linear growth
11	Huybregts et al.[26]	Chad	A Cluster RCT with intervention of 46 g of RUSF for 4 months on children aged 6-36 months.	Children with daily consumption of RUSF gained higher in height-for-age Z-score.
12	WHO[28]	-	Policy brief	Exclusive breastfeeding during the first 6 months, along with healthy and diverse complementary feeding

their chronological age to obtain more realistic results. Meeting the nutritional needs of stunted children aims for catch-up growth so that the child's height can reach their chronological age. However, current management for nutrition guidelines are heavily influenced by the severity and causes of malnutrition itself. For catch-up growth in infants, it is recommended to provide formula with an optimal protein-energy ratio of no more than 15% [27], while this percentage is still under-discussion. The recommended fat intake is 40% of energy needs, with an emphasis on high-quality fats. Fat provided should contain 15% of energy from monounsaturated fatty acids (MUFA), with oleic acid as the main source, saturated fatty acids (SFA) <10% of energy needs, Omega 6 Polyunsaturated Fatty Acid (PUFA) ranging from 4-8% with linoleic acid as the main source, and Omega 3 PUFA ranging from 0.5-2% of energy with alpha-linolenic acid as the main source. The lower limit of carbohydrate intake is 45% with an upper limit of 60% of total energy.

Protein Recommendation for Stunted children

The initial search obtained a total of 629 articles, where 35 articles were removed due to duplication. After reviewing the titles and abstracts, 585 articles were excluded due to irrelevant discussions. A total of 23 articles were reviewed in depth, where 12 articles did not report specific amount of protein recommendation, 1 article was a research protocol, and the rest focused on children with kidney disease. Therefore, 9 articles were included in this study (Fig. 2), consisting 2 RCTs, 1 non-RCT, 2 systematic reviews, 3 narrative reviews, and 1 recommendation document. The experimental studies were originated from Bangladesh, UK, and Jamaica.

Generally, the protein intake for stunted children to support catch-up growth is still inconclusive. Current guidelines, which may be used, refer to FAO[6] which states that the protein intake of children (1-2 years) for catch-up growth is 2.82 g/kg/day. However, this recommendation is based on limited data that represents human models using true ileal digestibility. Moreover, Pencharz[29] suggests a higher recommendation of protein intake for lean body mass repletion (1 g new lean tissue/day), amount-

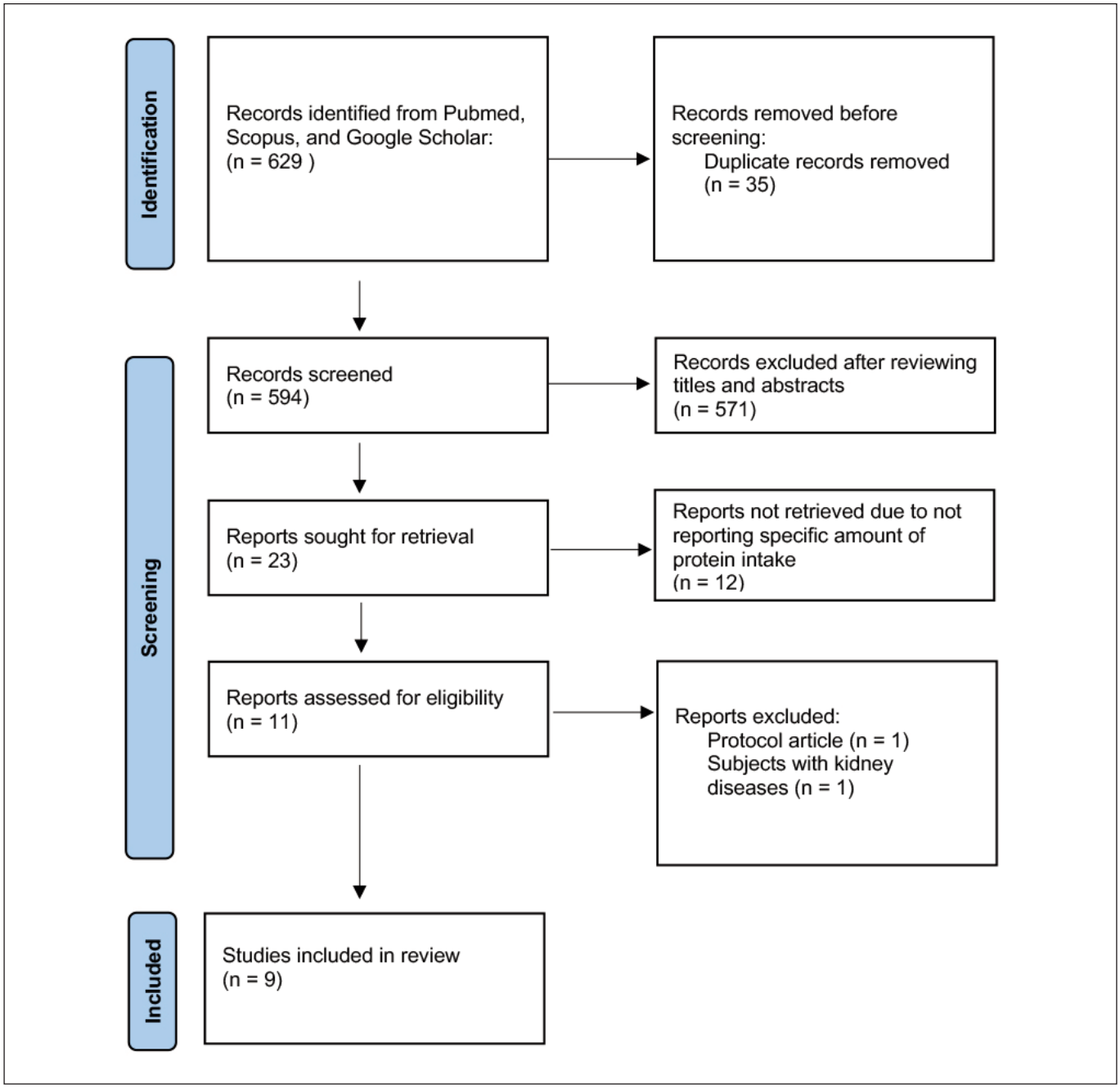

Figure 2. Prisma flow diagram for identifying study on protein intake for stunted children

ing to 3.7 g/kg/day. Higher protein recommendation is also found from the study by Doherty et al.[30] demonstrated that malnourished children might have effective catch-up growth by receiving 4.4 g protein/kg/day, considering higher weight gain and greater N balance. Another recommendation proposes that protein intake per day may reach 5.4 g/kg/day, depending on the composition of weight gain[31]. However, there is a possibility of having excess weight gain after high-protein diet intervention in stunted children. Providing more than 15% protein of total energy has been reported to increase the risk of obesity[27]. Meanwhile, administering standard protein intake (8-15% of energy or 1-1,1 g/kg BW) has been showed to support normal growth in stunted children[32-34]. Moreover, Golden[35] has proposed the specific amount of protein intake in moderate acute malnutrition: 24 g/1000 kcal.

Increased risk of obesity due to higher intake of protein in children has been reported by several previous studies. The most contributing study suggesting that a higher protein intake increases the risk of obesity is a CHOP study employing a randomized controlled trial (RCT) with 1138 children. The study found that mean weight, BMI, and z-score were higher in high-protein formula groups, respectively[36]. Moreover, follow-up of the CHOP study demonstrated that a high protein group had a higher risk of becoming obese (OR = 2.43; 95% CI: 1.12, 5.27)[9]. Moreover, a study in Indonesia showed an increase in energy intake and body weight after providing high protein snack to under-five children for 30 days[37].

As there is no robust data evaluating protein intake recommendations for stunted children, a theory hypothesis the emergence of obesity as an adverse effect of higher protein intake in growth catch-up. Increased protein intake may elevate the concentrations of amino acids, particularly branched-chain amino acids (BCAA), subsequently enhancing insulin and IGF levels through the rapamycin pathway in children[38]. This may increase the risk of adipogenesis, which then causes obesity. Another mechanism may involve methionine intake. Methionine participates in DNA methylation, which contributes to developmental programming. A prospective cohort study found that there was a significant association between higher intake of methionine and higher BMI among children aged 1 year[39]. Methionine participates in epigenetics through DNA methylation. Previous study showed methionine restriction produced a leaner phenotype in rats through increasing oxidation of lipids[40].

CONCLUSION

Protein plays a crucial role in children growth. Low protein intake has been linked to growth retardation and stunting. Present dietary guidelines is still partially providing recommendation for stunting children. Moreover, specific protein intake recommendations have not been firmly established. Nevertheless, several studies have suggested protein intake ranging from 2.8 to 5.4 g/kg/day for accelerating catch-up growth, considering factors such as age and body composition. However, a recent study have even indicated a risk of obesity associated with higher protein intake recommendations. Therefore, there is a strong need for more specific guidelines regarding dietary guidelines and protein intake recommendation in stunted children.

REFERENCE

1. WHO. https://www.who.int/data/gho/data/themes/topics/joint-child-malnutrition-estimates-unicef-who-wb. 2022. Joint Child Malnutrition Estimate.
2. TABOADA GARCÍA MA, ROMÁN LÓPEZ IR, del Rocío GORDILLO CORTAZA J, GONZÁLEZ GARCÍA WA, ESTRADA RODRÍGUEZ DR, BURGOS GARCÍA EG, et al. Factores asociados al retardo de crecimiento en niños menores de 5 años con cardiopatías congénitas. Revista Nutrición Clínica y Dietética Hospitalaria. 2023;43(4).
3. Rosidi A, Margawati A. The potency of socio-economic family and cultural factor in affecting stunting of Muna ethnic in Batalaiworu, Southeast Sulawesi. In: IOP Conference Series: Earth and Environmental Science. IOP Publishing; 2019. p. 012015.
4. Kaimila Y, Divala O, Agapova SE, Stephenson KB, Thakwalakwa C, Trehan I, et al. Consumption of animal-source protein is associated with improved height-for-age z scores in rural Malawian children aged 12–36 months. Nutrients. 2019;11(2):480.
5. Tang M, Krebs NF. High protein intake from meat as complementary food increases growth but not adiposity in breastfed infants: a randomized trial. Am J Clin Nutr. 2014;100(5):1322–8.
6. Shivakumar N, Jackson AA, Courtney-Martin G, Elango R, Ghosh S, Hodgkinson S, et al. Protein quality assessment of follow-up formula for young children and ready-to-use therapeutic foods: recommendations by the FAO Expert Working Group in 2017. J Nutr. 2020;150(2):195–201.
7. Scrimshaw NS, Waterlow JC, Schurch B. Energy and protein requirements: proceedings of an IDECG workshop. Eur J Clin Nutr. 1996;50.
8. Abrams SA, Hawthorne KM, Pammi M. A systematic review of controlled trials of lower-protein or energy-containing infant formulas for use by healthy full-term infants. Advances in Nutrition. 2015;6(2):178–88.
9. Weber M, Grote V, Closa-Monasterolo R, Escribano J, Langhendries JP, Dain E, et al. Lower protein content in infant formula reduces BMI and obesity risk at school age: follow-up of a randomized trial. Am J Clin Nutr. 2014;99(5):1041–51.
10. Cohen P. Overview of the IGF-I system. Horm Res Paediatr. 2006;65(Suppl. 1):3–8.
11. Widyawati SA, Suhartono S, Mexitalia M, Soejoenoes A. The relationship between pesticide exposure and umbilical serum igf-1 levels and low-birth weight: A case-control study in brebes, indonesia. Int J Occup Environ Med. 2020;11(1):15.
12. Fikawati S, Syafiq A, Ririyanti RK, Gemily SC. Energy and protein intakes are associated with stunting among preschool children in Central Jakarta, Indonesia: a case-control study. Malays J Nutr. 2021;27(1).

13. Rizky Maulidiana A, Sutjiati E. Low intake of essential amino acids and other risk factors of stunting among under-five children in Malang City, East Java, Indonesia. J Public Health Res. 2021; 10(2):jphr-2021.

14. Organization WH. Global nutrition targets 2025: Stunting policy brief. World Health Organization; 2014.

15. Arthur SS, Nyide B, Soura AB, Kahn K, Weston M, Sankoh O. Tackling malnutrition: a systematic review of 15-year research evidence from INDEPTH health and demographic surveillance systems. Glob Health Action. 2015;8(1):28298.

16. Darapheak C, Takano T, Kizuki M, Nakamura K, Seino K. Consumption of animal source foods and dietary diversity reduce stunting in children in Cambodia. Int Arch Med. 2013;6(1):1–11.

17. Penny ME. Micronutrients in the treatment of stunting and moderate malnutrition. In: Meeting micronutrient requirements for health and development. Karger Publishers; 2012. p. 11–21.

18. Asare H, Rosi A, Faber M, Smuts CM, Ricci C. Animal-source foods as a suitable complementary food for improved physical growth in 6 to 24-month-old children in low-and middle-income countries: A systematic review and meta-analysis of randomised controlled trials. British Journal of Nutrition. 2022;128(12):2453–63.

19. Byrd KA, Shieh J, Mork S, Pincus L, O'Meara L, Atkins M, et al. Fish and fish-based products for nutrition and health in the first 1000 days: a systematic review of the evidence from low and middle-income countries. Advances in Nutrition. 2022;13(6): 2458–87.

20. Iannotti LL, Lutter CK, Stewart CP, Gallegos Riofrío CA, Malo C, Reinhart G, et al. Eggs in early complementary feeding and child growth: a randomized controlled trial. Pediatrics. 2017;140(1).

21. Fikawati S, Adhi EK, Syafiq A, Bakara SM. Age of Milk Introduction is a Dominant Factor of Stunting Among Toddlers Aged 24 Months in Bogor District: A Cross-Sectional Study. Pakistan Journal of Nutrition. 2019 Sep 15;18(10):969–76.

22. Sjarif DR, Yuliarti K, Iskandar WJ. Daily consumption of growing-up milk is associated with less stunting among Indonesian toddlers. Medical Journal of Indonesia. 2019;28(1):70–6.

23. Organization WH. Guideline: assessing and managing children at primary health-care facilities to prevent overweight and obesity in the context of the double burden of malnutrition. 2017;

24. Stewart CP, Caswell B, Iannotti L, Lutter C, Arnold CD, Chipatala R, et al. The effect of eggs on early child growth in rural Malawi: the Mazira Project randomized controlled trial. Am J Clin Nutr. 2019;110(4):1026–33.

25. Tang M, Hendricks AE, Krebs NF. A meat-or dairy-based complementary diet leads to distinct growth patterns in formula-fed infants: a randomized controlled trial. Am J Clin Nutr. 2018;107(5): 734–42.

26. Huybregts L, Houngbé F, Salpéteur C, Brown R, Roberfroid D, Ait-Aissa M, et al. The effect of adding ready-to-use supplementary food to a general food distribution on child nutritional status and morbidity: a cluster-randomized controlled trial. 2012;

27. Hörnell A, Lagström H, Lande B, Thorsdottir I. Protein intake from 0 to 18 years of age and its relation to health: a systematic literature review for the 5th Nordic Nutrition Recommendations. Food Nutr Res. 2013;57(1):21083.

28. WHO U. Global nutrition targets 2025: breastfeeding policy brief (WHO/NMH/NHD14. 7). Geneva: World Health Organization. 2014;

29. Pencharz PB. Protein and energy requirements for 'optimal' catch-up growth. Vol. 64, European Journal of Clinical Nutrition. 2010. p. S5–7.

30. Doherty T, deBenoist MH, Hibbert J, Persaud C, Jackson AA. The effect of the level of dietary protein and the quality of dietary energy on urea kinetics in young children recovering from severe malnutrition. Proceedings of the Nutrition Society. 1989;48:55.

31. Joosten K, Meyer R. Nutritional screening and guidelines for managing the child with faltering growth. Eur J Clin Nutr. 2010;64(1): S22–4.

32. Arsenault JE, Brown KH. Effects of protein or amino-acid supplementation on the physical growth of young children in low-income countries. Nutr Rev. 2017;75(9):699–717.

33. Kabir I, Rahman MM, Haider R, Mazumder RN, Khaled MA, Mahalanabis D. Increased height gain of children fed a high-protein diet during convalescence from shigellosis: a six-month follow-up study. J Nutr. 1998;128(10):1688–91.

34. Clarke SE, Evans S, MacDonald A, Davies P, Booth IW. Randomized comparison of a nutrient-dense formula with an energy-supplemented formula for infants with faltering growth. Journal of human nutrition and dietetics. 2007;20(4):329–39.

35. Golden MH. Proposed recommended nutrient densities for moderately malnourished children. Food Nutr Bull. 2009;30 (3_suppl3):S267–342.

36. Koletzko B, Von Kries R, Closa R, Escribano J, Scaglioni S, Giovannini M, et al. Lower protein in infant formula is associated with lower weight up to age 2 y: A randomized clinical trial. American Journal of Clinical Nutrition. 2009 Jan 6;89(6):1836–45.

37. Permatasari O, Murwani R, Rahfiludin MZ. Tempe nuggets provision improves energy adequacy and protein intake in underweight underfive children. Current Research in Nutrition and Food Science Journal. 2018;6(1):89–96.

38. Luque V, Closa-Monasterolo R, Escribano J, Ferré N. Early programming by protein intake: the effect of protein on adiposity development and the growth and functionality of vital organs. Nutr Metab Insights. 2015;8:NMI-S29525.

39. Braun KVE, Voortman T, Kiefte-de Jong JC, Jaddoe VW V, Hofman A, Franco OH, et al. Dietary intakes of folic acid and methionine in early childhood are associated with body composition at school age. J Nutr. 2015;145(9):2123–9.

40. Orgeron ML, Stone KP, Wanders D, Cortez CC, Gettys TW. The impact of dietary methionine restriction on biomarkers of metabolic health. Prog Mol Biol Transl Sci. 2014;121:351–76.