Daily consumption of growing-up milk is associated with less stunting among Indonesian toddlers

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ABSTRACT
BACKGROUND In Indonesia, animal protein intake in children is low and might contribute to a high prevalence of stunting. This study was aimed to evaluate the association between animal protein source consumption and stunting in toddlers.

METHODS This cross-sectional study obtained secondary data from the Ironcheq questionnaire validation study to detect the risk of iron deficiency in toddlers. The Ironcheq study was carried out in five integrated health service posts (Posyandu) in Jakarta from 2013 to 2014. Data from 172 subjects, consisting of 41 stunted (height-for-age z-score less than -2) and 131 normal children, were analyzed to evaluate the association between animal protein source consumption and stunting using multivariate logistic regression test.

RESULTS Stunted children tend to come from a family with low parental education and socioeconomic status. Consuming growing-up milk (GUM) ≥300 ml/day was protective against stunting (adjusted OR 0.28, 95% CI 0.13–0.63), whereas consuming red meat product ≥5 times/week was a risk factor (crude OR 3.70, 95% CI 1.17–11.74), however after adjusted to age, sex, and other variables in the questionnaire, the OR was not significant (adjusted OR 3.64 95% CI 1.00–13.26).

CONCLUSIONS A daily consumption of 300 ml of GUM may be considered to prevent stunting in toddlers. Red meat products (sausage, nugget, and meatball), which are commonly consumed because of its practicality, could not be considered as significant animal protein sources because of a wide variation of their nutritional content.

KEYWORDS animal protein, growing-up milk, stunting, toddler

Stunting syndrome is a constellation of growth retardation, delayed development, cognitive defect, and metabolic defect, which increases morbidity and mortality in young children.[1–3] The prevalence was 22.2% worldwide in 2017,[4] and Indonesia has the fifth highest burden of stunted children in the world. Stunting decreases productivity in adults and yields a future stunted generation, creating the vicious cycle of poor national human resources. However, it can be reversed by improving maternal and child's nutrition,[2,5] as well as enhancing sanitation and healthcare facilities.

Nutrients are classified into type 1 and type 2 nutrients based on their effects on growth and deficiency symptoms. Type 1 nutrients (e.g., iron, copper, thiamin, niacin, and vitamins A/D/E/K) are required principally for specific metabolic body functions. The illness is recognized by characteristic signs and symptoms but does not directly affect growth. Well-known examples are anemia (iron deficiency), beriberi (thiamin deficiency), pellagra (niacin or nicotinic acid deficiency), and scurvy (vitamin C deficiency). Type 2 nutrient (protein, energy, zinc, potassium, sodium, magnesium, and phosphorus) deficiency provides the same picture of poor growth, stunting, and wasting.[1–3] Many studies worldwide found an association between children's linear growth and protein, especially animal source in the form of milk.[6] The effect of milk on linear growth is higher than other protein sources such as meat or egg and much higher than plant-based protein such as soy, legumes, and oats. That order is called nutritional value protein, as suggested by the Food and Agricultural Organization (FAO) in 2014 based on the content of essential amino acids, or the so-called limiting amino acids.[7,8] Animal protein contains more essential amino acids and sulfur-ring amino acids, which may promote linear growth better. Unfortunately, such studies that aim to find the food source that may be recommended to prevent stunting have never been carried out in Indonesia.

Indonesia is facing double-burden malnutrition problems, with the prevalence of stunting and overweight of 37% and 14%,[4] respectively. About 15 of its 29 provinces have a stunting prevalence of above 40%. The Indonesian South East Asian Nutrition survey study in 2012 found that the prevalence was around 25% in urban areas and 39% in rural areas and that the protein consumption was significantly different between the two areas in specific age groups (29 *versus* 21 g/day in 6–23 months old and 40 *versus* 30 g/day in 2–5 years old, respectively).[9] The aim of this study was to investigate the association between protein food source and stunting in toddlers, particularly the amount or frequency of consuming protein food source.

METHODS

Study participants and settings

This cross-sectional study was a part of a bigger study aimed to validate the Ironcheq questionnaire to detect the risk of iron deficiency in toddlers, which was carried out in five randomly selected integrated health service posts (Posyandu) in Central and East Jakarta from October 2013 to January 2014 involving 300 healthy children aged 1–3 years. This study used a questionnaire consisting of five questions (Table 1). Weight and height were measured by a research assistant, whereas dietary analysis was performed by a trained dietitian using a 3-day food record. Blood was obtained for complete blood count and iron profile. The report of this study has not been published (Table 1).

For this study, Allen's recommendation for research on stunting between two groups was the basis for the sample size estimation, in condition to detect 1 standard deviation (SD) difference of height/length-for-age z-score with p-value of 0.05 and power of 0.8.[10] In our study, the minimal sample size was 17

Table 1. Ironcheq questionnaire

Question	Score 2	Score 1	Score 0
How much formula or growing-up milk does your child drink in a day?	≥600 ml milk per day	About 300 to 600 ml milk per day	<300 ml per day or hardly any
How much portion of chicken or beef liver does your child onsume in a week? (A portion size of chicken liver equals to one liver, while a portion size of beef liver equals to the size of a matchbox)	5 portion sizes or more per week	2–4 portion sizes or more per week	1 portion size or less per week
How much portion of red meat (beef, lamb, or goat, not chicken nor fish) does your child consume in a week? (A portion size of red meat equals to the size of a matchbox)	5 portion sizes or more per week	2–4 portion sizes or more per week	1 portion size or less per week
How much portion of red meat products (beef sausage, corned beef, or beef meatball) does your child consume in a week? (A portion size of red meat equals to the size of a matchbox)	5 portion sizes or more per week	2–4 portion sizes or more per week	1 portion size or less per week
How many eggs (chicken, duck, or quail, both white and yolk) does your child consume in a week? (A portion size of chicken or duck egg equals to an egg, while a portion size of quail egg equals to three eggs)	5 portion sizes or more per week	2–4 portion size or more per week	1 portion size or less per week

subjects per group, and we classified them into either a stunted or a normal stature group. The stunted group was defined by height/length-for-age z-score less than -2 SD,[11] whereas the criteria for normal stature group were height/length-for-age z-score more than -1 SD. The criteria for normal stature were not based on the World Health Organization (WHO) but were specifically designed for our study to detect a minimal 1 SD difference of height/length-for-age z-score based on Allen's recommendation, which was used on sample size calculation. We also excluded those who were underweight (weight-for-age z-score less than -2 SD), wasted (weight-for-height/length z-score less than -2 SD), overweight (body mass index-for-age z-score more than 1 SD), or had height/length-for-age z-score between -2 and -1 SD. The exclusion criteria were determined to ensure that wasting and underweight do not bring a potential risk of confounding factors. This study has been approved by the Ethical Committee of Health Research, Faculty of Medicine, Universitas Indonesia No. 662/H2.F1/ETIK/2013.

Units of measurement

Stunting was defined as children who had height/length-for-age z-score less than -2 SD for their respective age and sex, according to the WHO 2006 standard growth chart. The z-scores were calculated using the WHO Anthro® software. Length in centimeters was measured in a supine position using SECA® length board for subjects under 2 years old, whereas height was measured in a standing position with SECA® stadiometer for those who are above 2 years old. Weight in kilograms was measured using SECA® digital scale in a standing position, and the subjects wore none or minimal light clothes. Paternal or maternal education status was classified as primary school, junior high school, senior high school, and undergraduate. Family economic status was classified based on monthly family income (World Bank, 2012): low (less than IDR 785.000), lower middle (IDR 786.000–2.500.000), upper middle (IDR 2.500.000–9.654.000), and high (more than IDR 9.654.000).

The Ironcheq questionnaire used in this study consisted of five items, namely, toddler formula (growing-up milk [GUM]), liver, red meat, red meat products, and eggs. Research assistants (general practitioner) asked the parents and filled in the questionnaire. Each question had a score of 0, 1, or 2 according to the amount or frequency of consumption (Table 1). The GUM is a specially formulated milk for children aged 1 to 3 years, which is fortified with micronutrients required for toddlers, such as iron, zinc, and vitamins, as regulated by CODEX STAN 72-1981 for follow-up formula.[11]

Statistics

All data were managed in accordance with human subject research and data confidentiality. Data distribution was analyzed using proportion or normality test if applicable, while association test was carried out using chi-square or Fisher exact test and then followed by simple logistic regression to measure odds ratio (OR) and its 95% confidence interval (CI). We adjusted potential confounders such as age, sex, and each other question using multiple logistic regression. We used STATA for Windows version 12.1 (StataCorp, Texas, USA) to carry out the statistical test, and a p-value of less than 0.05 was considered significant.

RESULTS

A total of 172 subjects were enrolled in our study, with 41 stunted and 131 well-nourished children. The subjects' profiles are shown in Table 2. Stunted children tend to be older and have male sex. Although statistically insignificant, paternal and maternal education status and family economic status may be inversely associated with stunting. Stunting prevalence tends to be higher in lower education and economic status (Table 2).

The Ironcheq questionnaire, which detects the risk of iron deficiency in toddlers, consists of five questions regarding the daily intake of iron sources, including GUM, red meat, liver, meat products, and egg. Those iron sources are animal protein sources, which have been shown as one of the several nutrients playing a role in stunting. The association between stunting and intake pattern of these five common animal protein sources in the Ironcheq questionnaire was analyzed using Fisher exact test as a bivariate analysis (Table 3, presented as crude OR). As consumption of GUM >600 ml/day will bring risk to toddler's obesity, we did a subgroup analysis regrouping the original three groups of milk consumption (<300, 300–600, and >600 ml/day) into two groups only, that is, <300 and ≥300 ml/day to see whether the protective effect

Table 2. Subjects profiles

Characteristics	Total, n (%) (n=172)	Stunted, n (%) (n=41)	Normal, n (%) (n=131)	p
Age (median, range)	23 (11–36)	27 (14–36)	22 (11–36)	**<0.01**
Male sex	77 (44.77)	21 (51.22)	56 (42.75)	0.341
Paternal education status				0.262
Primary school	9 (5.23)	3 (7.32)	6 (4.58)	
Junior high school	25 (14.53)	6 (14.63)	19 (14.50)	
Senior high school	115 (66.86)	30 (73.17)	85 (64.89)	
Undergraduate	23 (13.37)	2 (4.88)	21 (16.03)	
Maternal education status				0.068
Primary school	15 (8.72)	5 (12.19)	10 (7.63)	
Junior high school	40 (23.26)	15 (36.59)	25 (19.08)	
Senior high school	103 (59.88)	19 (46.34)	84 (64.12)	
Undergraduate	14 (8.14)	2 (4.88)	12 (9.16)	
Family economic status				0.697
Low	9 (5.23)	3 (7.32)	6 (4.58)	
Lower middle	100 (58.14)	25 (60.98)	75 (57.25)	
Upper middle	59 (34.30)	13 (31.70)	46 (35.11)	
High	4 (2.33)	0	4 (3.05)	

Table 3. Association between stunting and the five common animal protein sources

Food types	Amount or frequency	Stunted (n=41)	Normal (n=131)	Crude OR (95% CI)	p	Adjusted OR* (95% CI)	p
Growing-up milk (GUM)	≤300 ml/day	23	41	1.00		1.00	
	300–600 ml/day	6	20	0.36 (0.17–0.73)†	**0.005**‡	0.28 (0.13–0.63)†	**0.002**‡
	≥600 ml/day	12	70				
Liver	≤1×/week	27	99	1.00		1.00	
	2–4×/week	14	28	1.60 (0.75–3.43)§	0.222	2.03 (0.87–4.75)§	0.100
	≥5×/week	0	4				
Red meat	≤1×/week	39	119	1.00		1.00	
	2–4×/week	2	8	0.51 (0.11–2.37)§	0.389	0.54 (0.09–2.93)§	0.473
	≥5×/week	0	4				
Red meat products	≤1×/week	4	33	1.00		1.00	
	2–4×/week	15	49	2.53 (0.77–8.29)	0.126	2.31 (0.62–8.65)	0.214
	≥5×/week	22	49	3.70 (1.17–11.74)	**0.026**‡	3.64 (1.00–13.26)	0.050
Egg	≤1×/week	6	18	1.00		1.00	
	2–4×/week	13	49	0.80 (0.26–2.41)	0.686	0.46 (0.13–1.60)	0.219
	≥5×/week	22	64	1.03 (0.36–2.93)	0.954	0.43 (0.12–1.50)	0.187

*Adjusted for age, sex, and other variables in the questionnaire; †Re-group "300-600 ml" and "≥600 ml" due to dietary recommended intake of milk <30% of total calories or less than 500-600 ml/day for toddlers; ‡Significant p-value (<0.05); §Re-group "2-4x/week" and "≥5x/week" due to 0 subject in stunted group, respectively. OR=odds ratio; CI=confidence interval

could be reached by consuming GUM ≥300 ml/day. The results showed that two protein sources had a significant association with stunting, namely, GUM as a protective factor (OR 0.36, 95% CI 0.17–0.73) and red meat products as a risk factor (consuming ≥5 times/week showed OR 3.70, 95% CI 1.17–11.74). Further logistic regression test (Table 3, presented as adjusted OR) showed that consuming ≥300 ml/day of GUM is a protective factor for stunting (adjusted OR for age and sex 0.28, 95% CI 0.13–0.63, p=0.002) while for red meat products was not significant (adjusted OR 3.64, 95% CI 1.00–13.26, p=0.05).

DISCUSSION

Protein is a macronutrient composed of amino acids, whose quality is determined based on the body's ability to synthesize.[7] The human body could synthesize a number of amino acids (non-essential), but others are absolutely (essential) or conditionally (semi-essential) required from food. Amino acids have numerous regulatory roles in human growth and metabolism, such as hormone synthesis (growth hormone, insulin-like growth factor-1 [IGF-1], and thyroid hormone), cell membrane protein transporter or receptor, and long bone and joint formation.[7]

Some amino acids also have bigger roles in linear growth than others, such as arginine, lysine, and sulfur-containing amino acids (methionine and cysteine). Arginine and lysine stimulate growth hormone synthesis more significantly than other amino acids.[12] Lysine is a limiting amino acid in rice, which is a staple food in Indonesia. Methionine is a limiting amino acid in soybeans, and soybeans products such as tempeh and tofu are the most common protein sources in Indonesia. Sulfur is one of the type 2 nutrients,[2] and methionine stimulates gene expression related to growth hormone and IGF receptor synthesis and increases protein turnover in liver cells.[13]

The subjects' profiles are relatively similar between stunted and non-stunted children, except for age. Stunted children tend to be older, which could be explained by slower growth velocity that starts from 1 to 3 years of age.[1] In our study, the socioeconomic status, described as family economic status and paternal and maternal education status, has an inversed trend with stunting prevalence. This finding is similar to other studies that have shown that stunting is more common in the low socioeconomic status population,[4,5] which may be associated with the family's financial capacity to provide high nutritional food, especially protein food sources. A protein source is relatively more expensive than a carbohydrate or fat source. However, the difference in the proportion of socioeconomic status between groups was not statistically significant in our study.

Bivariate analysis (Table 3, presented as crude OR) showed that two protein sources had a significant association with stunting, with GUM consumption >300 ml/day as a protective factor (OR 0.36, 95% CI 0.17–0.73) and red meat products consumption >5 times/week as a risk factor (OR 3.70, 95% CI 1.17–11.74). Further logistic regression test (Table 3, presented as adjusted OR) showed that GUM was protective against stunting (adjusted OR 0.28, 95% CI 0.13–0.63), while red meat products was not statistically significant.

This study showed that milk protein has a superior characteristic compared with other animal protein (meat, poultry, and egg), which support linear growth. This result is consistent with a study in Danish toddlers, which proved that milk intake was positively associated with IGF-1 concentrations and height. An increase in milk intake from 200 to 600 ml/day corresponded to a 30% increase in circulating IGF-1.[14]

This result shows that a GUM consumption of 300 ml/day is associated with less stunting. The amount of milk is consistent with the WHO recommendation for the management of moderate acute malnutrition, as many as 25% to 33% of the protein sources should come from dairy protein as this would have a positive effect on weight gain and linear growth.[15] The protein content in 300 ml of GUM is around 8 g, whereas the protein requirement for children aged 1–3 years accounting for 1000 kcal/day to achieve a protein energy ratio of 12.5% is 31 g/day. Thus, the protein content in 300 ml of GUM meets 25.8% of the daily protein requirement for toddlers, which is consistent with the WHO recommendation.

The GUM used in this study is a specially formulated milk for children aged 1 to 3 years, which is fortified with micronutrients required for toddlers, such as iron, zinc, and vitamins, as regulated by CODEX STAN 72–1981 for follow-up formula.[11] The toddlers get the benefit from the fortification of micronutrients and milk protein in GUM, which helps to meet their requirement in addition to poor food intake. That is why the formula milk seems to be a protective factor to stunting, and we propose a recommendation that toddlers should consume at least 300 ml of formula milk daily to prevent stunting. In addition, a study in Vietnam showed that formula milk consumption in school-age children may lower the occurrence of underweight and stunting, improve micronutrient status, and improve learning indicator and quality of life.[16]

Contrary to GUM, we found red meat products to be a risk for stunting. Red meat products are any processed foods, such as sausages, corned meat, or meatballs, which consist of red meat mixed with starch and other ingredients (salt, sugar, food additive, emulsifier, and stabilizer). The commonly consumed red meat products in this study subject were of low quality, which means that they have very low red meat content and they mainly contain starch and salt. As such, consuming red meat products will replace the intake of nutritious food and put the toddler at risk of protein and micronutrient deficiencies.

FAO emphasized the importance of assessing protein quality in addition to its quantity for infants and young children.[7] The protein digestibility-corrected amino acid score (PDCAAS) approach is the current internationally approved method for protein quality assessment.[17–19] Animal protein has higher quality than plant protein. WHO emphasizes that the quality of protein should be high (PDCAAS >70%), but there is no firm recommendation for including milk protein.[19] However, it states that "the inclusion of milk powder as an ingredient improves the amino acid profile (has a high PDCAAS) and it is a good contributor of bioavailable calcium and potassium. In addition, it has a specific stimulating effect on linear growth and IGF-1 levels in the child and does not contain anti-nutrients.[20]

To our knowledge, this is the first study to investigate the association of animal protein food source intake with stunting in toddlers in Indonesia. In general, toddlers have distinct nutritional requirements and behavior as they may start to show food preference of family food. Breast milk or other milk is considered only an additional for them. The knowledge and behavior of the parents or caregivers could also affect infants and young children feeding practices, which is highly important for the children's well-being and health in the future. Inappropriate feeding practices and poor quality food provision result in malnutrition.[5]

There are a few limitations to this study. First, our study only focused on five protein sources because we used the Ironcheq questionnaire, which was primarily designed to detect the risk of iron deficiency, not stunting. There are other protein sources that are commonly consumed in Indonesia but were not assessed in our study, such as fish. Second, we did not assess the quantitative intake (g/day) but use an ordinal scale based on the estimation of the daily portion and food frequency per week instead. Quantitative dietary analysis using g/day could probably give a more precise recommendation.

To summarize, this study proved that GUM consumption has a significant association with stunting in Indonesian toddlers. On the other hand, red meat products should be reassessed for their nutritional quality. More efforts are needed to conduct a similar study on a larger scale and address for specific nutrients that may promote linear growth and reverse stunting. Most importantly, health practitioners, researchers, and the government should collaborate to reverse stunting in our future generation.

Conflict of Interest

The authors affirm no conflict of interest in this study.

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