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Energy and protein intakes are associated with stunting among preschool children in Central Jakarta, Indonesia: a case-control study

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ABSTRACT

Introduction: Stunting is a major nutritional problem in Indonesia. The prevalence of stunting in DKI Jakarta province was relatively high at 27.5% in 2013 and 17.7% in 2018. This study aims to describe nutrient intakes of children aged 25-30 months and to determine the proportional differences in nutrient intakes between stunting and normal children in Central Jakarta, Indonesia. **Methods:** A case-control study with a total sample of 121 children aged 25-30 months was conducted in Gambir and Sawah Besar sub-districts, Central Jakarta, where the prevalence of stunting was high. All children were exclusively breastfed for at least four months and had similar socio-economic levels. Data collected included height measurement, questionnaire-based interview, and 24-hour food recall. *T*-test and chi-square test were used to investigate the differences between two groups and logistic regression was used in multivariate analysis. **Results:** Factors associated with stunting were energy intake (*AOR*=6.0; 95% CI=1.0-35.0) and protein intake (*AOR*=4.0; 95% CI=1.1-15.5) after controlling for fat, carbohydrate, vitamin C, iron, and zinc intakes. The percentage of children with energy intake below the recommendation was much higher in stunted children (86.1%) compared to normal children (43.5%). Similarly, the percentage of children with protein intake below the recommendation was very much higher among stunted children (30.6%) compared to 8.2% in normal children. **Conclusion:** Children who lacked energy and protein intakes were at a higher risk of stunting than children who had sufficient intakes. Macronutrient intakes are important and should be consumed in sufficient quantities every day to prevent stunting.

Keywords: Stunting, energy intake, protein intake, preschool children, nutrient intake

INTRODUCTION

Stunting is a growth and development disorder that occurs in children aged 0-59 months, defined as length/ height-for-age <-2 standard deviations (SD) according to the World Health Organization (WHO) growth standards (WHO, 2010). According to WHO, stunting is caused by malnutrition, recurrent infections, and inadequate psychosocial stimulation. The short-term impact of stunting is related to

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the reduction of cognitive and physical developments in childhood, while the long-term impact of stunting is related to reduced productivity and work capacity as adults, as well as increased risk of degenerative diseases in the elderly (Hoddinott *et al*., 2013; Leroy & Frongillo, 2019).

In Indonesia, stunting is still a major nutritional problem in under-five children. In 2018, the prevalence of stunting in Indonesia was 30.8%, which meant that one in three toddlers in Indonesia was stunted (MOH RI, 2018). The prevalence of stunting in DKI Jakarta province, a capitol city of Indonesia, is also relatively high at 27.5% in 2013 and 17.7% in 2018 (MOH RI, 2018). The highest stunting prevalence in DKI Jakarta is occupied by the Central Jakarta area (29.2%), namely in Gambir and Sawah Besar sub-districts.

Direct factors that influence stunting are infection status and nutrient intake. Nutrient intake in infants, both macronutrient and micronutrient intakes, has a major role in growth (as measured by growth charts) and prevention of growth faltering (Elshazly & Haridy, 2018; Mzumara *et al*., 2018). Energy deficits occurring in under-five children would cause growth retardation and loss of fat and muscle (Tessema *et al*., 2018). Case-control studies on children in Iran and Bangladesh have shown a significant relationship between low carbohydrate intake and stunting (Esfarjani *et al*., 2013; Iqbal *et al*., 2019). Research has also shown the relationship between children's fat intake and stunting. Fat is a major component of many hormones, one of which is leptin, which has an effect on bone growth (Briend, Khara & Dolan, 2015; Mikhail *et al*., 2013).

Studies show that stunting is influenced by low intake of protein. Protein is significantly related to a child's length or height (Arsenault & Brown, 2017; Ghosh, 2016; Michaelsen *et al*., 2019). Chronic protein deficiency in under-five children causes growth to be impeded and becomes lower compared to growth standards. A survey on 75,548 children in 39 low- and middle-income countries showed that children who did not consume protein had a 1.4 times greater risk of stunting (Krasevec *et al*., 2017).

It is known that some micronutrients (vitamins and minerals) play important roles in the growth and development of children and thus have a relationship with stunting (Iqbal *et al*., 2019; Mikhail *et al*., 2013). Many studies have shown the positive contribution of vitamins A and C to the growth of healthy children (Mora, Iwata & Andrian, 2008; Pasricha & Biggs, 2010). Among minerals, studies have shown an association of calcium, iron, and zinc deficiency with stunting (Esfarjani *et al*., 2013; Iqbal *et al*., 2019; Pasricha & Biggs, 2010).

This study aims to describe nutrient intakes of children aged 25-30 months and to determine the proportional differences in nutrient intakes between stunting and normal children aged 25-30 months in Gambir and Sawah Besar sub-districts, Central Jakarta, Indonesia. In the study area, to obtain a sufficient number of children younger than 24-month old with stunting was difficult, therefore, we extended the age range to 30 months old. The percentages of children 25 months old and those older than 25 months were 70.2% and 29.8%.

MATERIALS AND METHODS

This study was an observational study with a case-control design using quantitative approach. The study was conducted in Gambir and Sawah Besar sub-districts, Central Jakarta from October to December 2019. These sub-districts have the highest stunting prevalences in Central Jakarta District. Respondents were 121 children aged 25-30 months old divided into two groups: 36 children in the case group and 85 children in the control group. To calculate the minimum sample size in this study, the two proportions formula was used. Based on previous research, it was found that the largest number of sample was 35 children. The case-control ratio used to determine the sample was 1:2, thus the number of cases was 35 children and number of controls was 70 children. However, when data collection was carried out, there were 36 children who came to the Integrated Health Service Post (*Posyandu)* for the case group and 85 children for the control group, hence all of them were included as research subjects.

Respondents resided in the Gambir sub-district (townships of Cideng, Petojo Utara, Petojo Selatan, and Duri Pulo) and in the Sawah Besar sub-district (townships of Karang Anyar, Mangga Dua Selatan, Kartini, and Pasar Baru). The case group consisted of children who were stunted at the start of the study based on anthropometric measurements conducted by enumerators, with stunting defined as height-for-age *z*-score <-2SD, while the control group had children who were not stunted at the time of the study. Matched co-variables were history of exclusive breastfeeding for at least four months and socio-economic level derived from *Posyandu* data in the same region.

The dependent variable in this study was stunting and the independent variables were macronutrient intakes (energy, protein, fat, and carbohydrate) and micronutrient intakes (vitamin A, vitamin C, calcium, iron, and zinc). Confounding variables in this study were the number of family members, father's education, mother's education, father's occupation, mother's occupation, family income, mother's nutritional knowledge, and infectious diseases.

Primary data collection was carried out by six enumerators with a background in public health nutrition education from the Faculty of Public Health, University of Indonesia. Enumerators were trained for two days with materials related to stunting, interview methods, and data collection mechanism in the field. Nutritional status data based on height-for-age and weight-for-age were obtained from anthropometric measurements. Measurement of height was carried out twice to get accurate results. The instrument used was a microtoise with duplo measurement. To get accurate results, calibration was carried out before taking measurements. Daily consumption and nutrient intakes were collected using the 24-hour food recall method in the beginning of the study, and food intake data were converted to nutrient intakes using Nutrisurvey (free license).

After data cleaning, univariate and bivariate analyses were conducted using chi-square and independent *t*-test. Variables with *p*-values <0.25 in the bivariate analysis were included in the multivariate analysis using logistic regression. Odds ratios (with 95% confidence intervals, CI) were calculated to determine the relationship between stunting and independent variables. Collinearity and interactions between the independent variables were examined and no collinear variables were found.

Before the interview, respondents were informed about the research and asked about his/her willingness to take part in the research. Respondents were also asked to fill in and sign an informed consent. This research has been approved by the Ethics Commission of the Research and Community Service Institute at Atma Jaya University (Reference number: 1154/III/LPPM-PM.10.05/09/2019).

RESULTS

Data from a total of 121 respondents aged 25-30 months were successfully collected. The results of the study showed that stunting was more common in boys (61.1%). Both stunted (72.2%) and non-stunted (69.4%) children had small family size. Father's education in stunted and non-stunted children were similar, which was high school. Most fathers of both groups had work (94.4% in the case group and 96.5% in the control group), while most mothers do not work (83.3% in the case group and 77.6% in the control group). Both stunted and non-stunted children tended to come from families with low incomes.

Based on the mother's education, there was a significant difference between stunted and non-stunted children, namely 52.8% of stunted children had

Table 1. Characteristics of children aged 25-30 months in case and control groups

Variables	*Case n=36*	*Control n=85*	*Total respondents n=121*	*p-value*
	n (%)			
Gender of children				
Male	22 (61.1)	37 (43.5)	59 (48.8)	0.12
Female	14 (38.9)	48 (56.5)	62 (51.2)	
Number of family members				
Large (>4 people)	10 (27.8)	26 (30.6)	36 (29.8)	0.93
Small (≤4 people)	26 (72.2)	59 (69.4)	85 (70.2)	
Father's education				
Low, ≤Junior High School	12 (33.3)	27 (31.8)	39 (32.2)	1.00
High, ≥Senior High School	24 (66.7)	58 (68.2)	82 (67.8)	
Mother's education				
Low, ≤Junior High School	19 (52.8)	24 (28.2)	43 (35.5)	0.02*
High, ≥Senior High School	17 (47.2)	61 (71.8)	78 (64.5)	
Father's occupation				
Does not work	2 (5.6)	3 (3.5)	5 (4.1)	0.63
Work	34 (94.4)	82 (96.5)	116 (95.9)	
Mother's occupation				
Does not work	30 (83.3)	66 (77.6)	96 (79.3)	0.65
Work	6 (16.7)	19 (22.4)	25 (20.7)	
Family income				
<Minimum salary level	26 (72.2)	47 (55.3)	73 (60.3)	0.12
≥Minimum salary level	10 (27.8)	38 (44.7)	48 (39.7)	
Mother's nutrition knowledge				
Low	14 (38.9)	27 (31.8)	41 (33.9)	0.58
High	22 (61.1)	58 (68.2)	80 (66.1)	
ARI history				
Yes	9 (25.0)	18 (21.2)	27 (22.3)	0.82
No	27 (75.0)	67 (78.8)	94 (77.7)	
Diarrhea history				
Yes	6 (16.7)	8 (9.4)	14 (11.6)	0.35
No	30 (83.3)	77 (90.6)	107 (88.4)	

*Statistically significant at *p*-value ≤0.05

Table 2. Proportions of macronutrient and micronutrient intakes among children with and without stunting

Variables	*Case n=36*			*Control n=85*			*p-value*
	Less (<80% RDA)	*Good (≥80% RDA)*	*Mean intake*	*Less (<80% RDA)*	*Good (≥80% RDA)*	*Mean intake*	
	n (%)			*n (%)*			
Macronutrient							
Energy	31 (86.1)	5 (13.9)	864.7	37 (43.5)	48 (56.5)	1344.9	<0.01*
Protein	11 (30.6)	25 (69.4)	29.7	7 (8.2)	78 (91.8)	40.0	<0.01*
Fat	28 (77.8)	8 (22.2)	35.1	44 (51.8)	41 (48.2)	50.2	0.01*
Carbohydrate	33 (91.7)	3 (8.3)	115.0	55 (64.7)	30 (35.3)	157.4	0.01*
Micronutrient							
Vitamin A	22 (61.1)	14 (38.9)	391.4	31 (36.5)	54 (63.5)	714.0	0.02*
Vitamin C	31 (86.1)	5 (13.9)	18.6	43 (50.6)	42 (49.4)	58.9	<0.01*
Calcium	31 (86.1)	5 (13.9)	275.3	53 (62.4)	32 (37.6)	555.0	0.02*
Iron	31 (86.1)	5 (13.9)	3.2	40 (47.1)	45 (52.9)	7.8	<0.01*
Zinc	17 (47.2)	19 (52.8)	2.8	27 (31.8)	58 (68.2)	4.5	0.16

*Independent t-test, statistically significant at p-value ≤0.05

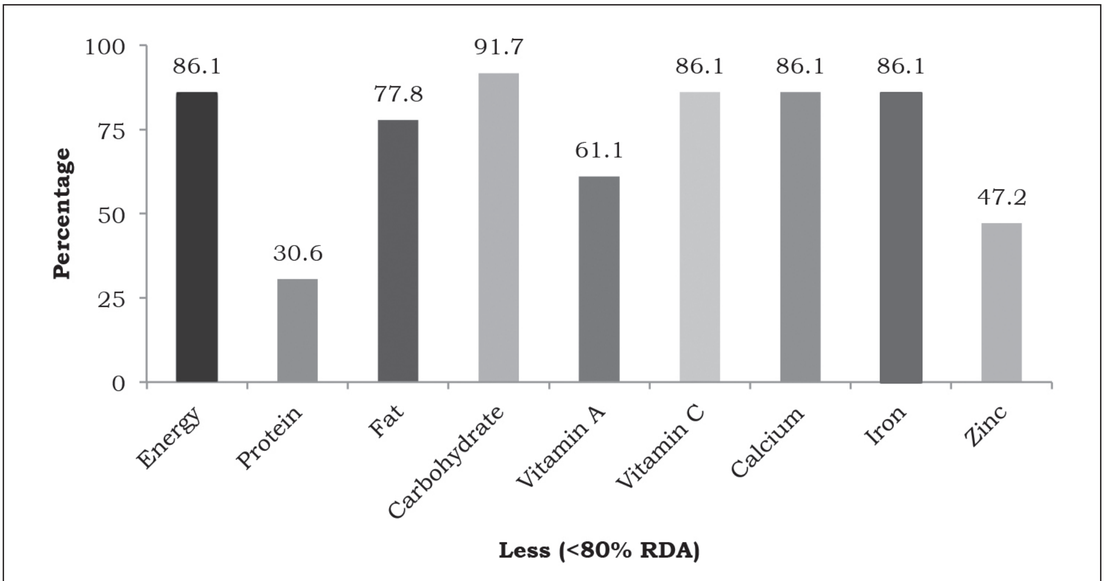

Figure 1. Percentages of macronutrients and micronutrients adequacy in case group

mothers with low education, while in non-stunted children, most of the mothers had higher education (71.8%). In terms of history of illness, there was no significant difference between the two groups. Most stunted and non-stunted children did not have a history of infectious diseases, either acute respiratory infection (ARI) or diarrhoea. Stunted children tended to have mothers with low nutritional knowledge compared to non-stunted children. The characteristics of the children according to case and control groups can be seen in Table 1.

This study showed that majority of stunted children consumed energy, fat, carbohydrates, and protein lesser than the recommended nutritional adequacy, namely 86.1%, 77.8%, 91.7%, and 30.6%, respectively (Table 3). In comparison, the percentages of non-stunted children with intakes less than the recommendation were 43.5%, 51.8%, 64.7%, and 8.2%, respectively. The average energy intake of stunted children was significantly lower (865 kcal/day) compared to the average energy intake of non-stunted children (1345 kcal/day). Similarly, the average protein intake of stunted children was lower (29.7 g/day) compared to non-stunted children (40.0 g/day). Both fat and carbohydrate intakes were also observed to be lower among stunted children (35.1 g/day and 115.0 g/day) compared to non-stunted children (50.2 g/day and 157.4 g/day) (Table 2).

The percentages of stunted children with micronutrient intakes (vitamin A, vitamin C, calcium, iron, and zinc) below the recommended nutritional adequacy were 61.1% for vitamin A, 86.1% for vitamin C, calcium and iron, and 47.2% for zinc. Meanwhile, the percentages of non-stunted children with micronutrient intakes (vitamin A, vitamin C, calcium, iron, and zinc) below the recommended nutritional adequacy were 36.5% for vitamin A, 50.6% for vitamin C, 62.4% for calcium, 47.1% for iron, and 31.8% for zinc. Adequacy of micronutrients in non-stunted children exceeded the recommended adequacy of nutrients,

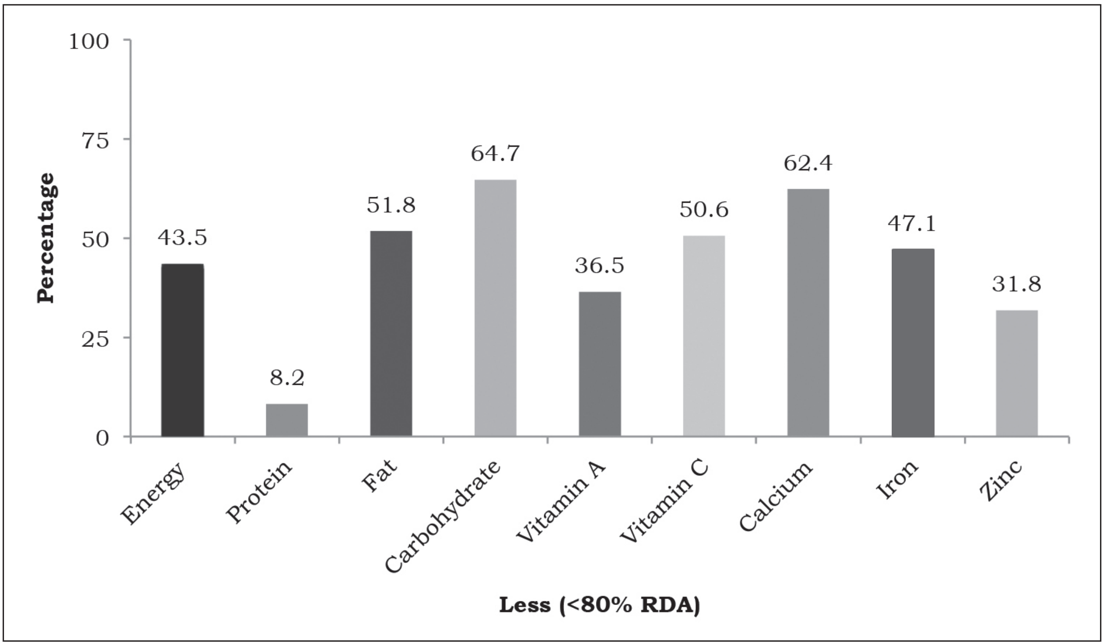

Figure 2. Percentages of macronutrients and micronutrients adequacy in control group

except for calcium, where non-stunted children consumed an average of 555.0 mg/day and stunted children were significantly lower at only 275.3 mg/day (the recommendation is 650.0 mg/day). The proportions of macronutrient and micronutrient intakes among children with and without stunting are displayed in Table 2. Percentages of macronutrients and micronutrients adequacy in case and control groups are presented in Figure 1 and Figure 2, respectively.

Nine nutrients included in the multivariate analysis were energy, protein, fat, carbohydrate, vitamin A, vitamin C, calcium, iron, and zinc intakes. The analysis showed that factors associated with stunting were energy intake (*AOR*=6.0; 95% CI=1.0-35.0) and protein intake (*AOR*=4.0; 95% CI=1.1-15.5) (Table 3). Children with energy intake less than recommendation had six times greater odds for stunting than those with sufficient energy intake. Children whose protein intake was less than recommended had four times greater odds for stunting than those with sufficient protein intake.

DISCUSSION

In terms of demographic and socio-economic characteristics, the two groups in this study were relatively similar. Significant difference was found only in maternal education, whereby stunted children had mothers with lower levels of education than non-stunted children. These results are similar to other studies in Nigeria and Nairobi, which reported that low-educated mothers have limited knowledge, especially regarding child feeding, food choices, and health seeking practices, which consequently contribute to stunting (Abuya, Ciera & Kimani-murage, 2012; Fadare *et al.*, 2019).

Results of this study indicated that children with energy intake less than recommendation have six times greater risk of stunting than children whose

Table 3. Multivariate analysis of factors associated with stunting

Variables	*Case n=36*	*Control n=85*	*Total respondents n=121*	*p-value*	*Adjusted OR (95% CI)*
	n (%)				
Energy intake					
Less (<80% RDA)	31 (86.1)	37 (43.5)	68 (56.2)	0.05*	6.0 (1.0-35.0)
Good (≥80% RDA)	5 (13.9)	48 (56.5)	53 (43.8)		
Protein intake					
Less (<80% RDA)	11 (30.6)	7 (8.2)	18 (14.9)	0.04*	4.0 (1.1-15.5)
Good (≥80% RDA)	25 (69.4)	78 (91.8)	103 (85.1)		
Fat intake					
Less (<80% RDA)	28 (77.8)	44 (51.8)	72 (59.5)	0.25	0.4 (0.1-2.0)
Good (≥80% RDA)	8 (22.2)	41 (48.2)	49 (40.5)		
Carbohydrate intake					
Less (<80% RDA)	33 (91.7)	55 (64.7)	88 (72.7)	0.52	1.8 (0.3-10.1)
Good (≥80% RDA)	3 (8.3)	30 (35.3)	33 (27.3)		
Vitamin C intake					
Less (<80% RDA)	31 (86.1)	43 (50.6)	74 (61.2)	0.11	2.7 (0.8-9.1)
Good (≥80% RDA)	5 (13.9)	42 (49.4)	47 (38.8)		
Iron intake					
Less (<80% RDA)	31 (86.1)	40 (47.1)	71 (58.7)	0.09	3.2 (0.8-11.9)
Good (≥80% RDA)	5 (13.9)	45 (52.9)	50 (41.3)		
Zinc intake					
Less (<80% RDA)	17 (47.2)	27 (31.8)	44 (36.4)	0.12	0.4 (0.1-1.3)
Good (≥80% RDA)	19 (52.8)	58 (68.2)	77 (63.6)		

* Multiple logistic regression, statistically significant at $p \leq 0.05$

energy intake was sufficient (*AOR*=6.0; *95% CI*=1.1-40.0). These results are in line with a randomised controlled trial study conducted by Tessema *et al.* (2018) in rural Ethiopian children aged 6-35 months (*n*=873), who reported that stunted children had significantly lower daily energy intakes than non-stunted children (Tessema *et al.*, 2018). Several other studies also reported similar findings that there was significant relationship between energy intake and stunting (Abebe, Haki & Baye, 2018; Iqbal *et al.*, 2019).

This study also revealed that children with protein intake less than recommendation had four times greater risk of stunting than children whose energy intake was sufficient (*AOR*=4.0; 95% *CI*=1.1-15.5). A study of 873 children in Ethiopia showed that a lack of protein intake, both in quality and quantity, has a significant relationship with stunting. Intakes of tryptophan, protein, and energy, as well as serum levels of tryptophan and insulin-like growth factor 1 (IGF-1) in serum, are positively correlated with the linear growth of children (Tessema *et al.*, 2018). Stunting has a close relationship with protein intake that functions to stimulate insulin in IGF-1 (Millward, 2017; Dror & Allen, 2011). In a study in Bogor District, Indonesia, Fikawati *et al.* (2019) reported that toddlers with inadequate protein intake were almost three times more likely to suffer from stunting compared to children with adequate protein intake. Another study in Bogor found that the majority of children (87.0%) consumed grains, such as rice and bread, while consumption of eggs, legumes, and animal source foods were low (Trisasmita *et al.*, 2020).

There were significant relationships between energy and protein intakes with stunting after controlling for fat, carbohydrate, vitamin C, iron, and zinc intakes. The results of this study are similar to studies among toddlers aged 25-60 months in Mangkung Village, District of Central Lombok (Anshori, Sutrisna, Fikawati, 2020), which found that among 372 toddlers randomly sampled from *Posyandu*, macronutrient intakes (energy and protein) had significant relationships with stunting incidence.

The results implied that macronutrients are most important to overcome stunting in this population. They support the possible neglect of macronutrient deficiencies among children in developing countries amid the dominance of micronutrient deficiency narratives. Semba (2016) pointed out that protein is the missing essential nutrient to growth in the diet, meanwhile micronutrients supplementation showed limited or no efficacy towards stunting (Semba, 2016; Stammers *et al.*, 2015; Mayo-Wilson *et al.*, 2014). Iqbal *et al.* (2019) found that in low-resource settings, global deoxyribonucleic acid (DNA) methylation was higher among children with low protein, carbohydrate and energy intakes. Stunted children has a higher DNA methylation. This study therefore emphasises the importance of macronutrient sufficiency in preventing stunting among children 2-3 years old.

Low animal source protein intake may relate to the higher prevalence of stunting in Indonesia. Sjarif, Yuliarti & Iskandar (2019) reported that two protein sources had significant associations with stunting, namely growing-up milk and red meat products. The national data on individual food consumption revealed that animal source protein consumption among under-five children was very low, i.e., 39.8 g/day of fish, 20.1 g/day of eggs, 29.4 g/day of meat, and 22.6 g/day of fresh milk (MOH RI, 2014).

The lack of significance between micronutrient and stunting in this study could be caused by several factors. The data showed that micronutrient intakes were closer to recommendation than macronutrient intakes. Moreover, micronutrient serum level was not associated with DNA methylation in the Iqbal study. This could be related to low protein intake, level of body stores, infection status, and bioavailability (Iqbal *et al.*, 2019). This result does not undermine the importance of micronutrients in relation to their roles in linear growth, rather it shows that emphasis on micronutrients booming in recent years should be balanced by re-establishing the importance of macronutrients.

This study has several limitations. Firstly, it cannot ascertain a causal relationship due to temporal factors in the case-control study design. Secondly, this study did not measure some variables associated with the linear growth of children such as environmental sanitation and hygiene. Thirdly, there is a possibility of distorted reporting, which is a potential problem in all dietary assessment methods, and it is not known to what extent parents reported their child's food intake, as well as neglected or discounted for leftovers. We assumed that the data reflected daily consumption since the variety of foods and beverages at this age range is limited, and also that the socio-economic levels of the subjects in these two groups were similar. Fourthly, there is a possibility that sample size was too small as indicated by the large range of confidence interval. Thus, future studies should consider to add more samples.

Based on the results of this study, a priority should be given to nutritional programmes that emphasise increasing energy and protein intakes. The effects of consumption of high-quality energy and protein foods, especially animal protein, in supporting the linear growth of children must be further investigated with the design of longitudinal intervention studies. Through robust longitudinal studies, it can be ascertained that the contribution of nutrients, both macro- and micronutrients, in the increase of linear growth among children. The amount of energy and protein intakes must be calculated by considering various factors beforehand, such as infectious diseases and the nutritional condition of the child.

CONCLUSION

The results showed that after controlling for fat, carbohydrate, vitamin C, calcium and zinc intakes, energy and protein intakes were factors associated with stunting among children aged 25-30 months in Gambir and Sawah Besar sub-districts, Central Jakarta. Children whose energy and protein intakes were below recommendation had six and four times, respectively, higher risk of stunting than children with sufficient intakes. Macronutrients are important and should be consumed in sufficient quantities every day to prevent stunting.

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Authors' contributions

SF, principal investigator, conceptualised and designed the study, prepared draft of the manuscript, reviewed and revised the manuscript; AS, conducted data analysis and interpretation; RRK, collected and analysed data, and SCG, analysed data and added new related references for manuscript.

Conflict of interest

No conflict of interest.

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