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Protein, Magnesium and Phosphorous Intake at Stunted and Non-Stunted Children in Panularan Surakarta

Endang Nur Widiyaningsih[1*], Aulia Putri Wahyuningtyas[2]
Universitas Muhammadiyah Surakarta
*****_enw239@ums.ac.id_

Abstract
The first five years of children's life are a very important period of growth and development because it will determine the success of children's growth and development in the future. One of the nutritional problems occurs in children under five is stunting. We aimed to determine the mechanism of the inadequacy of protein, magnesium and phosphorus intake to stunting in children under five. This study involved 35 stunted children and 35 non-stunted children aged 12 to 60 months. The subjects were selected by simple random sampling technique. The data of protein, magnesium and phosphorus intake was obtained through 24-hour dietary recall in four times on nonconsecutive days. Most stunted and non-stunted children under five have a higher intake of protein, magnesium and phosphorus than the Recommended Daily Allowance. Average intake of protein, magnesium and phosphorus in non-stunted children are, respectively, 78.69 points, 124.57 points, and 117.04 points, which are higher than stunted children under five. There are differences in the adequacy of protein, magnesium and phosphorus intake in the stunted and non-stunted groups (p = 0.007, p = 0.011, and p = 0.003).

Keywords: Protein, Magnesium, Phosphorus, Stunting, Children under five

1. Introduction

The first five years is a very important period to determine the nutritional status of children in the future. Children with less nutritional status will experience obstacles in their growth and development. The problems related with undernutrition are still a major problem in children under five. Stunting indicates a lack of chronic malnutrition caused by nutritional intake that is not sufficient to the nutritional needs that last for a long time and can affect growth, brain development, and immune system (Victora et al., 2008). Stunting occurs in the first one thousand days of life will have an impact on functional impairment, decline in cognitive function, and decrease work productivity (Bloem et al., 2013). The prevalence of stunting in Indonesia was 37.2% in 2013 and increased by 1.6% from 35.6% in 2010, and increased by 0.4% from 36.8% in 2007. In Surakarta area, the prevalence of stunting in children under age five was 12.7%. The prevalence was also recorded by Penumping Public Health Centre of 19.69%, Gilingan Public Health Centre of 16.07%, and Stabelan Public Health Centre of 12.93%. Nutritional status of a person is also influenced by the metabolism of the body. The interference in the metabolic process of a nutrient can inhibit the process of metabolism of other nutrients in the body. The process of protein metabolism requires vitamins and minerals thus the insufficiency of vitamins and minerals will disrupt the metabolic processes in the body (Bloem et al., 2013). Protein intake is a factor that can affect height in children in which those who have less protein intake are at a higher risk of experiencing stunting. In addition to the influence of macronutrients, such as carbohydrates, proteins, and fat, stunting can also be affected by micronutrients, such as vitamin A, zinc, iron and iodine. Although protein has a significant role for growth, other micronutrients, including calcium and phosphorus, also have important role in the child's growth (Elango, Humayun A., Ball, & Pencharz, 2011). Phosphorus deficiency can disrupt the growth process because the phosphate binds calcium to form a complex bond that can strengthen the bones. Long-lasting phosphorous deficiency causes osteomalacia and calcium-bone release (Li, Yuan, Guo, Sun, & Hu, 2012). Another micronutrient that also plays a significant role is magnesium because it is required by the body and it is involved in more than 300 essential metabolic reactions. In addition, it is used for energy metabolism, use of glucose, protein synthesis, synthesis and breakdown of fatty acids, muscle contraction, all ATPase functions, almost all hormonal reactions and maintenance of cellular ionic balance. It also affects calcium homeostasis in two mechanisms. *First*, some calcium channels depend on magnesium. When intracellular magnesium concentration is high, calcium transport into cells and from the sarcoplasmic reticulum is repressed. Secondly, magnesium is required for the release and action of parathyroid hormone. It is associated with an average plasma calcium in which a person who has experienced a diagnosis of plasma has a low calcium plasma that will affect the process of bone growth in the body (Gropper, S.S; Smith, 2013). Preliminary study found out the highest prevalence of stunting recorded by Penumping Public Health Centre was in Panularan village with the number of children under age five who suffered stunting was 54 children or 29.35% of 184 children. The data obtained from Penumping Public Health Centre was the record from August to September 2016.

2. Subjects and Methods

2.1 Setting and Design

The design of this study was observational with cross-sectional approach. It was conducted in Panularan village, Laweyan sub-district, Surakarta. Data collection took place in October to November 2016. The population of this study was all children aged 12-60 months who regularly visit the Maternal and Child Health Services. Subsequently, the participants were classified into two groups, namely stunted and non-stunted group, according to the World Health Organization (WHO) standard. Children under five with height-for-age less than −2 SD of the WHO standard were included in stunted group, while those with height-for-age more than +2 SD of the WHO standard were categorized into non-stunted group. The respondents were the mothers of those children.

2.2. Samples

The children involved in this study were 70 children under five consisting of 35 stunted children and 35 non-stunted children in healthy condition. They live and settle with parents, as well as had a willingness to be the participants in this research. Simple random sampling technique was employed to select the participants. The first step to determine the sample was by measuring the weight and height of all the children who regularly visit the Maternal and Child Health Services. It was followed by the calculation of children's nutritional status using WHO Anthro application. Subsequently, the children were divided into stunted and non-stunted group based on their nutritional status. Children who were classified as stunting as many as 54 children under five and who meet the inclusion criteria of 53 children under five, then from 53 children under five taken at random to get a sample of 35 children under five stunting. Children who were categorized into non-stunted were 131 children under five and who were fulfilled inclusion criteria as many as 128 children under five. From these 128 children under five, randomly sampling was done to obtain a sample of 35 non-stunted children (Fig. 1). This research has earned Ethical approval from Health Research Ethics Committee of Faculty of Medicine, Universitas Muhammadiyah Surakarta No: 350/B.1/ KEPK-FKUMS/X/2016.

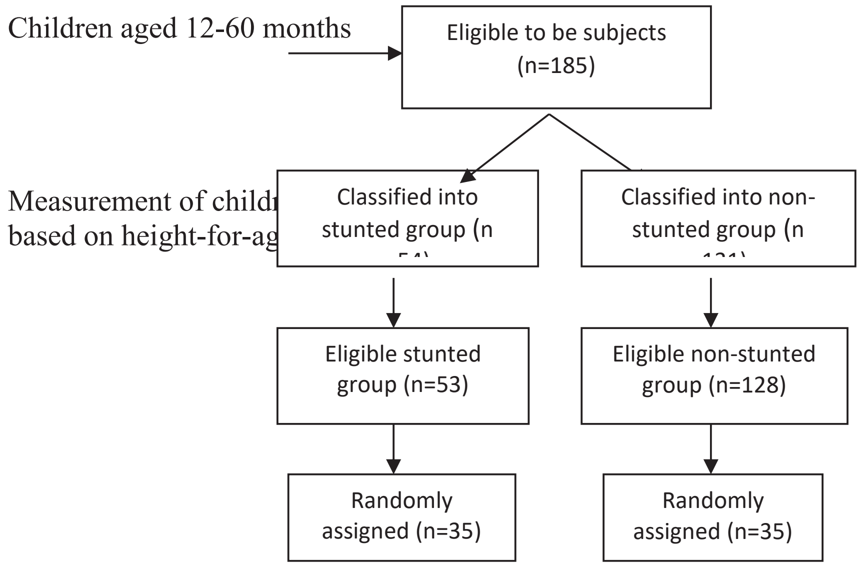

Fig. 1. Sampling flowchart.

2.3. Method of data collection

Data of nutritional status were obtained from anthropometric measurement of height using microtoice or baby board and subsequently calculated based on height-for-age index using WHO Anthro application. Nutritional status in children under five was categorized into two groups, namely stunted group if z-score < -2SD and non-stunted group if z-score ≥ -2SD. Data of protein, magnesium, and phosphorus intake of the samples were obtained based on 24-hour dietary recall for 4 days. The tool used in this recall process was food picture. Furthermore, the average was compared with Recommended Daily Allowance (RDA) with gram unit (g) using Nutrisurvey 2007 software. Data was analyzed using SPSS for Windows version 20.0 and analysis was in the form of descriptive analysis. Gender, age of children under five, univariate analysis was used to describe variables, namely protein, magnesium, and phosphorus intake. Testing of data normality for protein, magnesium and phosphorus intake variable using Kolmogorov-Smirnov test with p value = 0.131 ($p > 0.05$), p = 0.158 ($p > 0.05$), and p = 0.011 ($p < 0.05$), respectively, which means protein and magnesium intake were normal distribution data, whereas the data of phosphorus intake was not normal distribution data. Analyses were conducted with the Statistical Package for the Social Sciences (SPSS) version 21. Statistical significance was defined as $p < 0.05$. The values were the differences between the groups mean and 95% CIs. Analysis of difference in normal distributed data using independent t-test while the data was abnormally distributed using Mann-Whitney U test.

3. Results

3.1 Characteristics of Panularan Village

Panularan village is a densely populated residential area in the middle of Surakarta city. Most of the houses are close to each other separated only by narrow streets and some areas belong to slum settlements. The residents of Panularan village are mostly industrial laborers, traders, and some other livelihoods. The economic status of people in Panularan village is classified into middle-class group and some people are included in lower-class group. It can indirectly affect food intake on children and will affect the nutritional status of children under five, especially the index of height by age.

3.2 Subject Characteristics

Data obtained from the results of the study included the distribution of children under five based on their gender and age as demonstrated in Table 1.

Table 1
Subject Characteristics

Variable	Group			
	Stunted		Non-stunted	
	N	%	n	%
Gender				
Male	16	45.7	16	45.7
Female	19	54.3	19	54.3
Age (month)				
12-36	28	80	23	65.7
37-60	7	20	12	34.3

As demonstrated in Table 1, the number of female children was higher, both in the stunted and non-stunted group. The category of age this research was divided into two group, namely group of 12-36 months and group of 37-60 months. Most of the subjects aged between 12 to 36 months. The oldest subject was 58 months and the youngest subject was 14 months. The average age of the subjects was 29.39 months ± 12.08.

3.3 Intake of Protein, Magnesium and Phosphorus

Protein, magnesium and phosphorus intake in the stunted and non-stunted group were analyzed. The results showed the stunted group can be classified into the category of mild to moderate deficiency (**Table 2, 3** and **4**).

Table 2
Distribution of Protein Intake

Protein Intake Category	Group			
	Stunted		Non-stunted	
	n	%	n	%
Severe Deficiency	2	5.7	0	0
Moderate Deficiency	4	11.4	0	0
Mild Deficiency	1	2.9	0	0
Normal	4	11.4	2	5.7
Over	24	68.6	33	94.3

None of the subjects included in the non-stunted group endured protein deficiency. On the contrary, 20% of subjects in the stunted group were classified having protein deficiency. Nevertheless, more than half of protein intake in stunted and non-stunted children under five has average intake of more than 90% based on RDA. The growth process in children under five requires a higher protein intake in compared with adults since in the process, there will be an increase in the total amount of protein in the body. Protein deficiency may inhibit the rate of growth because protein plays an essential role in transporting nutrients from the digestive tract (Uribarri & Calvo, 2013). Long-term protein deficiency will lead to non-optimal growth (Krebs et al., 2012).

Table 3
Distribution of Magnesium Intake

Magnesium Intake Category	Group			
	Stunted		Non-stunted	
	n	%	n	%
Severe Deficiency	1	2.9	1	2.9
Moderate Deficiency	3	8.5	0	0
Mild Deficiency	1	2.9	0	0
Normal	3	8.5	4	11.4
Over	27	77.2	30	85.7

Magnesium intake of stunted group can be categorized into deficient in compared with the non-stunted group. Nevertheless, most stunted and non-stunted children had a higher magnesium intake. More than half of children in stunted and non-stunted group have over magnesium intake. Approximately 50% to 60% of magnesium in the body can be found in the bone. In the bone, magnesium is divide into two, namely the magnesium binding to phosphorus and the calcium lying on the crystal lattice (approximately 70%) and the magnesium found on the amorphous surface (approximately 30%). Magnesium on the surface of the bone is able to maintain the magnesium concentration in the body while the magnesium that is inside the crystal lattice is used during the process (Soetan, Olaiya, & Oyewole, 2010).

Table 4
Distribution of Phosphorus Intake

Phosphorus Intake Category	Group			
	Stunted		Non-stunted	
	N	%	n	%
Severe Deficiency	8	22.9	4	11.4
Moderate Deficiency	3	8.5	1	2.9
Mild Deficiency	4	11.4	1	2.9
Normal	7	20	3	8.5
Over	13	37.2	26	74.3

The deficiency of phosphorus intake in stunted group was higher than non-stunted group. The level of severe deficiency of stunted group is twice higher than non-stunted group. Otherwise, over intake of non-stunted group is twice higher than stunted group. The major minerals required in the process of bone formation in the body are calcium and phosphorus. If the body experiences both minerals deficiency continuously, the growth process of children can be hampered. Phosphorus and calcium have very close functions and the metabolic processes are interconnected. Calcium and phosphorus work together in the calcification process that is the formation of mineral matrix. Thus, calcium and phosphorus play a role to strengthen the bones in the body (Uribarri & Calvo, 2013). The imbalance of calcium and phosphorus dietary could decrease parameters of the tibia, such as calcium and phosphorus content, and stimulate the levels of calbindin mRNA. This condition will influence the growth of bone (Prentice et al., 2006). The average day of protein, magnesium and phosphorus intake are described in Table 5.

Table 5
Distribution of nutrient intake at stunted and non-stunted group

Nutrient	Group		*p* value
	Stunted (n =35)	Non-stunted (n=35)	
Protein (g/day)	50.49±33.04	74.77±36.62	0.007
Magnesium (mg/day)	138.94±73.97	233.51±147.74	0.011
Phosphorus (mg/day)	703.89±564.31	1288.79±1090.93	0.003

Values are means ±SD. Analyzed by independent T Test (Protein and Magnesium) and Mann Whitney Test (phosphorus); p<0.05.

4. Discussion

The analysis of protein, magnesium and phosphorus intake in two groups indicated that there are significant differences ($p < 0.05$). The growth of bones in humans begins with cartilage synthesis and subsequently the cartilage undergoes ossification. Cartilage synthesis requires sulfur, while the body obtains sulfur through the amino acid catabolism of methionine and cysteine, the amino acid itself is a protein-making molecule, it requires adequate protein intake or foods containing high amino acid sulfur for children (Ramezani Tehrani et al., 2013). The adequacy of protein is essential to bone mineralization and supported by the adequacy of magnesium and phosphorus (Prentice et al., 2006).

Magnesium is needed by transferter in the process of connective tissue synthesis, namely xylosyl transferase and glycosyl transferase. Glycosyl transferase plays a role in the synthesis of glycosaminoglycans, such as the sulfate condominium which will then bind with proteins to form proteoglycans. Proteoglycans are important structural components in connective tissue, such as cartilage and bone. Decreased intake of magnesium is often associated with physiological malfunctions in the human body, signs and symptoms of magnesium deficiency include: nausea, vomiting, dermatitis, elevated serum calcium, phosphorus, and alkaline phosphate (associated with skeletal changes), and bone formation disorders and skeletal defects (Gropper, S.S; Smith, 2013). The low Magnesium diet in rat decreased body weight and lean body mass, demonstrating that dietary Magnesium restriction after weaning impairs the growth of lean body mass (Bertinato et al., 2016).

Phosphorus has functions as a constituent of bones, teeth, adenosine triphosphate (ATP), phosphorusylated metabolic intermediates and nucleic acids. It serves buffering action, that is, phosphate buffers, functions in the formation of high energy compounds, that is, adenosine triphosphate (ATP) and is involved in the synthesis of phospholipids and phosphoproteins (Soetan et al., 2010).

Protein and phosphorous are found in dairy and meat product, fish, tofu, tempe, nuts cereal, seafood while magnesium source are green vegetable, nuts, seafood, cereal. Actually, the sources of protein, magnesium and phosphorus are almost the same. High dietary patterns in protein (e.g. dairy, legumes, and meat products) and carbohydrates (e.g. fruits, sweets, and desserts) might be associated with reduced odds of being stunted among children in Tehran Iran (Esfarjani, Roustaee, Mohammadi-Nasrabadi, & Esmaillzadeh, 2013). Stunting was a much larger driver of underweight for age than wasting. But the cause of stunting is multi factors (Walker, Chang, Wright, Osmond, & Grantham-McGregor, 2015). Besides dietary factors, other variables, such as hereditary factors and metabolic conditions must be considered (Steenkamp, Lategan, & Raubenheimer, 2016). Finally, this study provides evidence that inadequate intake of protein, magnesium and phosphorus is the most important nutritional cause of stunting.

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