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The Role of Nutrients and MCV on Stunting: A Case Study on Indonesian Early Teenagers

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Abstract

BACKGROUND: Many teenagers experience many nutritional problems, including anemia and stunting. The correlation between energy intake, protein, iron, and stunting with MCV levels in stunting adolescents in Jatinangor is not yet known.

AIM: This study aims to analyze the correlation of energy intake, protein, iron, and stunting and MCV levels in stunting adolescents in Jatinangor.

METHODS: This study was conducted with a cross-sectional design involving early adolescents aged 10–14 years in Jatinangor District as many as 41 people. Analysis of MCV levels was done by taking blood through veins. Stunting data were obtained based on the WHO criteria with a value of z-score TB/U<- 2 SD and nutritional intake data including energy, protein, and iron obtained through 24 h recall. To determine nutrient intake, interviews were conducted using the 24 hour recall and FFQ methods. The data were analyzed with the Pearson correlation test.

RESULTS: The correlation between energy intake and MCV levels was p = 0.022 (r = 0.356). Furthermore, the correlation of protein intake and MCV levels was p = 0.257, and iron intake with MCV levels was p = 0.301. Eventually, the stunting correlation test to MCV levels was p = 0.006 (r = 0.419).

CONCLUSION: This study concludes that there is a correlation between energy intake and the value of the z-score TB/U index with MCV levels. There is no significant correlation between protein intake and iron intake with MCV levels in stunting adolescents in Jatinangor. There is a correlation between MCV and stunting levels, and there is no correlation between nutrient intake and stunting.

Introduction

Stunting is a chronic manifestation of an extended energy and protein deprivation period that illustrates poor growth. This condition has long-term effects on individuals and society, including reduced cognitive and physical development, productivity, poor health, and more significant risk factors for degenerative diseases [1]. Research in China shows that stunting events in poor areas lack energy and protein that last quite a long time [2].

Chronic malnutrition in childhood affects stunting events in adolescence and adulthood [3], [4]. Adolescence is the most vulnerable age to health problems because they tend to limit their consumption related to appearance [3]. The United Nations Children's Fund (UNICEF) reports that the prevalence of stunting in Indonesia is 36%. According to the National Basic Research of Indonesia (RISKESDAS), the highest prevalence of stunting is in adolescent boys (13 years old) at 40.2%. Meanwhile, the highest stunting was occurred in girls as much as 35.8% (11 years old group). In the age group of 13–15 years, energy consumption is 59.1%, and protein is 44.2% below the minimum requirement [5]. By 2018, the prevalence of stunting under 2 years in Indonesia was 30.1%, and by 2020, the prevalence increased to 31.8% [6], [7].

Intake of nutrients lacking in the long term in childhood will affect the incidence of stunting in adolescence and adulthood. Body composition in stunting adolescents has more fat mass than fat-free mass. Fat-free mass in the human body is divided into several forms, one of which is protein [8]. Globin proteins bind to heme derived from iron to form hemoglobin. If protein and iron in the body are present in small amounts, then hemoglobin is also formed a little. The condition will become more severe in subjects with low protein and iron intake. In addition, the lack of energy, protein, and iron intake will cause the red blood cells that form to be smaller, which is illustrated in the low value of MCV in the blood. This condition will cause microcytic anemia [9], [10]. Research in India shows that respondents who experience stunting are more susceptible to anemia than average stature. The correlation between energy intake, protein, iron, and stunting with MCV levels in stunting adolescents has not been reported [11].

Methods

Study design and setting

This research is descriptive-analytical research with cross-sectional study methods. Before the data collection, this study had received approval from the health research ethics committee of the Faculty of Medicine, Universitas Padjadjaran, with number 713/ UN6.C2.1.2/KEPK/PN/2014. Subjects willing to be respondents are given informed consent to parents to know the research process and its benefits.

Research subjects

The study subjects were early adolescents aged 10–14 years and had stunting based on the category WHO TB/U <-2 elementary schools living in Jatinangor Subdistrict. Height measurements were undertaken by a stadiometer tool seca 215 then converted based on TB/U with the WHO Anthro Plus software.

Subject location

The sampling locations are at Paripurna Elementary School in Cinta Mulya, Cikeruh Elementary School in Cikeruh Village, Jatinangor Junior High School in Cisempur Village, and Al-Aqsa Junior High School in Cibeusi Village, Jatinangor district.

Data collection

The collection of nutritional intake data is done through a live interview on food intake using the 24 h recall method and consumption patterns with the FFQ method. Then, the subject of a blood sample was taken from a 3 cc vein to find out the subject's hemoglobin and MCV levels.

Results

Table 1 shows the characteristics of respondents.

Table 1: Characteristics of gender and age

Characteristic	Total (n = 41)	Percentage
Gender		
Boys	18	44
Girls	23	55
Age		
10 years	11	27
11 years	13	32
12 years	6	15
13 years	9	22
14 years	2	5

This research involved 44% of boys and 55% of girls. Regarding the age group of distribution, the largest of respondents in the age of 11 years, which is 13 people (32%), and the fewest number of respondents are respondents with the age of 14 years, which is only 2 people (5%).

Data on energy intake, protein intake, iron intake, stunting, and MCV levels are listed in Table 2.

Table 2: Data on energy intake, protein intake, iron intake, stunting, and MCV levels

Characteristic	Total (n = 41)	Percentage
Energy intake		
Good	10	24
Less	31	76
Protein intake		
Good	9	22
Less	32	78
Iron intake		
Good	4	10
Less	37	90
Stunting		
Short	36	88
Very short	5	12
MCV rate		
Usual	5	12
Low	36	88

Table 2 shows that most respondents have an average energy intake of fewer than 31 people (76%). The average protein intake of respondents was also <32 people (78%). The respondents with less iron intake were 37 people (90%), and the level of short stunting was 36 people (88%). Hemoglobin levels of respondents with normal categories were as many as 35 people (85%) and for respondents with low hemoglobin as many as six people (15%). Respondents had normal MCV levels as many as 5 people (12%) and respondents had low MCV levels as many as 36 people (88%). Pearson correlation test results between variables are listed in Table 3.

Table 3: Test correlation of energy intake, protein, iron, and value z-score TB/U with MCV levels

Variable	Average ± SD	MCV (fL)	
		Pearson test	r
Energy intake (kcal)	1382.83 ± 431.45	0.022*	0.356
Protein intake (gram)	39.46 ± 16.75	0.257	0.181
Iron intake (mg)	5.67 ± 4.21	0.301	0.165
Nilai z-score TB/U	−2.46 ± 0.39	0.006*	0.419
MCV (fL)	78.52 ± 5.22	1.000	1.000

*There is a correlation.

Table 3 shows that the respondents' average energy intake was 1382 ± 431.45 calories, the average protein intake was 39.46 ± 16.75 g, and the average iron intake was 5.67 ± 4.21 g. The average anthropometric index of height by age (TB/U) for respondents was –2.46 ± 0.39 and the average MCV rate was 78.52 ± 5.22 fL.

Based on the Pearson correlation test ($p \leq 0.05$), there was a weak positive correlation between energy intake and MCV levels in stunting adolescents of r = 0.356. In addition, there was no significant correlation between protein intake and MCV levels in stunting adolescents (r = 0.181). Similarly, there was no significant correlation between iron intake and MCV levels in stunting adolescents of r = 0.165. The correlation test results found a moderate positive correlation between stunting and MCV levels in stunting adolescents of r = 0.419.

Table 4 shows a significant correlation between MCV levels and stunting events, with a positive correlation strength of r = 0.42. While in the intake of nutrients, there is no significant association with the incidence of stunting in adolescents. The study was conducted *cross sectional,* so it has not described the whole situation.

Table 4: Correlation of nutrients and MCV with stunting

Variable	Average	Correlation
MCV (fL)	78.52 ± 5.22	0.006*
Energy (kcal)	1382.83 ± 431.45	0.293
Protein (gram)	39.62 ± 17:25	0.561
Fat (gram)	41.30 ± 7:27 PM	0.627
Carbohydrates (grams)	214.45 ± 88.49	0.888
Vitamin A	5187.21 ± 4536.70	0.654
Beta-carotene	61.36 ± 199.23	0.246
Thiamine	0.08 ± 0.19	0.523
Riboflavin	0.03 ± 0.09	0.827
Niacin	1.56 ± 2.28	0.938
Vitamin C	11.98 ± 25.86	0.306
Iron (Mg)	5.50 ± 4.06	0.493
Calcium	272.84 ± 188.75	0.436
Phosphorus	437.88 ± 178.88	0.802
Magnesium	412.56 ± 214.12	0.623
Zinc	0.68 ± 0.95	0.122

*There is a correlation.

Discussion

Macronutrient

Energy metabolism plays a key role in growth and development. Energy imbalance will affect the decrease in plasma insulin so that the level of insulin growth factor-1 (IGF-1) synthesized by the liver will also be reduced. The decrease results in performance in IGF-binding protein-1, leptin, thyroid hormone, growth hormone, and other metabolism that all affect linear growth. Whereas, in childhood, linear growth is strongly influenced by growth hormone [12]. A Tehran study of elementary school students showed that adherence to consuming carbohydrates and proteins was closely related [13]. Other studies have also confirmed a close relationship between energy and stunting in elementary school children [2].

The problem of protein deficiency is widely found in poor and developing countries. It has to do with social and economic issues. However, the need for protein in the growth and development of a person is significant [1]. The amount of protein consumption is small, and the protein quality is not very good, contributing to the body's lack of protein and amino acids [12]. Proteins are the main elements that structure and influence the function of DNA as a controller of the growth process by regulating its properties and characteristics. In addition, protein as a constituent of IGF-1, a mediator of growth hormone quality, is greatly influenced by the amount and type of protein. Lack of protein will inhibit the production of IGF-1, thus stimulating osteoblasts. If this happens continuously for a long time, linear growth will also be stunted [14], [15].

In the stunting condition, the function of fat as an energy reserve due to lack of protein consumption is highly relied on to maintain the body's basal metabolism. The most vital parts of body fat are sterols, including hormone synthesis [10]. However, consumption of high-fat foods in short children is not enough to improve height, so other nutrients are needed to support the growth of the chase [16]. The stunting group had a lower fat oxidation rate than the normal group. This condition is due to the low hormone adiponectin released by fat cells [17]. The results align with Tworoger's research showing a correlation between adiponectin levels and growth of human growth [18].

The FFQ analysis results obtained information that the snacks of respondents in school mostly came from foods made from tapioca flour and sugary drinks with a high enough sugar content. Children aged 2–3 years globally experience an increase in DNA methylation due to low protein and carbohydrates. This leads to changes that induce gene expression in growth [19]. A study in the Gambia showed that supplementation high in fat and carbohydrates could not improve his height. Therefore, other nutrients are needed to catch up with a person's high growth [16].

Micronutrient

The process of bone maturation has a good correlation to the level of growth at puberty. Adolescents who experience stunting have a low bone mass density, while adults have a high prevalence of osteoporosis. Osteoporosis may be one complication of stunting [10], [20]. In adolescence, hormones function actively so that calcium balance is still maintained. However, calcium is lost due to calcium deficiency, impaired absorption, or overspending [21].

Research in Bangladesh shows that giving mineral powder given in feeding babies born with low birth weight can significantly reduce the incidence of stunting. Increased minerals, including calcium, phosphate, and magnesium, can be achieved during the 1st 2 years of life and adolescence [22]. Phosphorus is the second most common mineral in the body and is an indispensable part of DNA and RNA for the growth process. About 85% is found along with calcium in hydroxyapatite crystals in bones and teeth. Strength in bones is affected by the mineralization process of hydroxyapatite crystals. If the ratio of these two minerals is not appropriate or lacks, it will affect bone density and growth. The balanced calcium: phosphorus ratio is 1:1 or 2:1, ideal for bone growth. Phosphate plays a role in energy metabolism, cell metabolism, membrane function, coenzymes, nucleotide metabolism, and bone mineralization [15].

In exclusively breastfed babies, minerals are expected to be obtained from the maximum from breast milk for growth. Therefore, the consumption of mothers while breastfeeding must also be appropriately considered. In children younger than 2 years of age, breast milk and companion food are expected to meet their needs. Additional minerals in the body can come from dairy products, fortified formula, and fish. This food will maximize the fulfillment of the needs of children and adolescents during the growth and development of children within a decade, who began to highlight the quality of local foods that under-meet the minerals needed to maximize growth, including iron, calcium, and zinc [22].

Zinc is found in bones and muscles. Zinc deficiency was first discovered in the 1960s in children and adolescents, causing stunted growth. In addition, zinc deficiency also causes poor digestion and absorption of nutrients and causes diarrhea that further worsens the incidence of stunting [10]. Children who experience stunting have low levels of zinc in the blood. It is caused by low zinc or poor absorption of zinc [23]. These results align with Gibson's research that zinc plays a key role in linear growth. Zinc levels in blood plasma are lower in stunted children than in children whose growth is normal. Low-energy and some micronutrients essential for growth are found in many preschoolers. If this micronutrient deficiency is lacking, growth becomes stunted, and the process of growing chasing at its peak is not achieved [24].

Vitamin A participates in protein synthesis and cell differentiation and supports reproductive and growth functions. In men, Vitamin A plays a role in sperm development, in women supporting fetal development during pregnancy. Children deficient in Vitamin A will experience growth failure [25]. Animal studies have shown the role of Vitamin A in the growth and maturation of epiphyseal cartilage cells and in inducing cessation of long bone growth. Other studies experimentally and clinically showed a very severe Vitamin A deficiency. Research in Uganda shows that Vitamin A deficiency is highly associated with stunting events [26].

Food sources of sufficient energy are beneficial to maintaining the body's needs, including growth and development. Nevertheless, optimizing cell metabolism in generating energy also depends heavily on vitamins that work directly. Vitamin B plays many roles as coenzymes in cell metabolism [14].

Vitamin C works a lot with B vitamins as cofactors that help certain enzymes. In other roles, Vitamin C is also vital in maintaining endurance. In children who experience malnutrition, especially in the slum area, it is very vulnerable to experience the incidence of infection and other diseases due to environmental and social conditions. Zinc helps reduce the risk of diarrheal events in children with more significant health risks so that the inhibition of growth due to infectious diseases does not get worse [23].

Correlation of nutrients and MCV levels in stunting

The results found a significant correlation between energy and adolescent MCV stunting levels, with a low correlation strength of r = 0.356. This is because the average energy of respondents is less than the required RDA of 1382.3 kcal (66%). Less energy consumption causes a lack of optimal formation of red blood cells, so the formed red blood cells will become smaller than their original size (microcytic). The smaller size of red blood cells causes the contents of red blood cells to be less, including hemoglobin. If it occurs over a long time, the body will experience a lack of iron stores and eventually experience iron deficiency anemia [27].

This study aligns with Kaur's research in the Fatehgarh Sahib area, which showed a strong positive correlation between energy and anemia. The respondent's energy had met daily needs and normal hemoglobin levels and was found in normal-looking adolescents [28]. Similarly, Barugahara's research on 109 normal stature schoolchildren ages 11–14 in Uganda's Masindi area showed a strong positive correlation between anemia and energy insufficiency. The difference in the results of this study was closely related to differences in metabolic ability between adolescents of normal stature with stunting adolescents, differences in the energy of respondents, and the number of study samples [29].

Other studies found no significant correlation between protein and MCV levels in stunting adolescents (r = 0.181). There was no suspected correlation in this study because the protein quality was not good (most consumed vegetable protein). In addition, other nutrients in the food consumed also affect the absorption of protein. The average protein respondent was also less than the required RDA of 39.46 g (64.5%). Protein plays an essential role in red blood cell formation and is part of hemoglobin formation. Several functions related to iron metabolism and red blood cell formations are highly protein dependent [30].

The results of this study are in line with Kaur's research in the Fatehgarh Sahib area, Punjab, which showed a significant correlation between anemia and protein in adolescent boys and young women [28]. In conditions lacking protein, the hormone erythropoietin, which helps the process of red blood cell formation, will be reduced. Hence, this results in reduced red blood cell work so that the red blood cells produced become less than optimal. The number of red blood cells produced becomes smaller (microcytic). Foods high in protein will increase iron absorption [9], [14].

In this study, the most commonly consumed source of vegetable protein is peanuts in the form of peanut seasoning. Vegetable protein did contribute a lot to respondents' proteins, but the quality of absorption of vegetable protein in the body was much less than animal protein. The amount of protein consumption is small, and the protein quality is not very good, contributing to the body's lack of protein and amino acids. Therefore, using protein in the body as a red blood cell forming material is less than optimal. Low sources of patient protein are generally due to a lack of food consumption of animal protein sources [30].

The study's results on iron and MCV levels in stunting adolescents found no significant correlation due to the quality of iron and the influence of other nutrients in iron absorption in the body. Table 3 shows the average iron respondent of 5.67 g or less than the needs recommended by RDI (30.6%). A lack of iron will interfere with the synthesis of red blood cells. At an advanced stage, the bone marrow will attempt to replace iron deficiency by speeding up cell division and producing blood cells smaller than the typical normal size (microcytic), thus causing low erythrocyte-bound hemoglobin levels to below. Hemoglobin synthesis decreases, so red blood cells become pale (hypochromic) and small (microcytic).

This study aligns with Ekpo *et al*. research involving 418 respondents of girls of normal stature aged 12–18 years in the Akwa Ibom area of Nigeria. The results of study obtained insignificant results with a weak positive correlation between iron and anemia showed ($r = 0.212$, $p > 0.05$) [9]. Sufficient iron is essential for the formation of hemoglobin to prevent the occurrence of anemia in teenagers of normal stature. Other nutritional factors that need to be considered as confounding factors are other nutritional factors such as zinc, copper, and calcium that affect iron absorption and non-nutrients such as tannins [31], [32].

The study results between stunting and MCV levels in stunting adolescents found a significant correlation with the strength of the correlation of $r = 0.419$. This study is in line with Kurniawan *et al*. research involving 133 young women of normal stature aged 10–12 years in coastal areas in Indonesia showed no difference in anthropometric index height-to-age between adolescents who have anemia and not anemia ($p = 0.756$) [33]. Different results were obtained in Fond des Blancs and Villa of Haiti study involving 557 children aged 6–59 months. The results showed a correlation between stunting and anemia [34], [35]. Food that is less than RDA for an extended period and begins to reduce iron stores in the body causes the production of red cells in the bone marrow to be disrupted. The cells formed will become smaller than their original size (microcytic). Smaller blood cell sizes will bring hemoglobin to less [36]. A small amount of hemoglobin is the cause of defensive iron anemia. Stunting children generally experience a long period of caloric deficiency, and in general, they also lack other micronutrients, including iron [34].

Conclusion

This study concludes that there is a correlation between energy intake and stunting events in adolescents. There is no relationship between nutrient intake and stunting. The results correlated either energy with MCV levels or body height with MCV levels in stunting adolescents. On the other hand, neither there is a significant correlation between the amount of proteins with MCV levels nor between iron and MCV levels. No significant relation is also suspected because the recall was conducted only 24 h, so further research was carried out by increasing the number of samples and the number of days during the recall to reflect daily intake better.

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