

RESEARCH STUDY

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Food Consumption Pattern Affects Vitamin D Levels and Quality of Life in Children during the Second Growth Spurt Period

Pola Konsumsi Makanan Mempengaruhi Kadar Vitamin D dan Kualitas Hidup Anak pada Masa Growth Spurt Kedua

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Received: 05-12-2021

Accepted: 21-07-2022

Published online: 03-03-2023

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DOI:

[10.20473/amnt.v7i1.2023.45-53](https://doi.org/10.20473/amnt.v7i1.2023.45-53)**Available online at:**<https://e-journal.unair.ac.id/AMNT>**Keywords:**

Consumption pattern, Growth spurt, Quality of life, Vitamin D, Semarang

ABSTRACT

Background: The second growth spurt period needs attention related to the intake of macro-nutrients and micro-nutrients, including vitamin D. So far, the evaluation of vitamin D has received less attention if indoor activity patterns exacerbate it and imbalanced food consumption patterns, it raises concern to trigger vitamin D deficiency and affect the children growth, development and quality of life.

Objectives: To determine the relationship between children's consumption patterns on vitamin D levels, weight, height, and quality of life of children aged 10-12 years.

Methods: Observational research with the cross-sectional design was conducted on 40 children 10-14 years old without physical disability from Pondok Kun Assalam Sentono and Madrasah Ibtidaiyah At-Taqwa Semarang, Indonesia. All subjects were measured consumption patterns using the Food Frequency Questionnaire (FFQ), blood levels of vitamin D, height, weight, leg length, and quality of life measured using the Pediatric Quality of Life Inventory (PedsQL).

Results: The results showed that out of 40 subjects, only 3 (7.5%) children had sufficient vitamin D levels (≥ 30 $\mu\text{g/mL}$). There was a significant relationship between food consumption patterns and blood vitamin D levels ($p < 0.01$), height, weight, leg length, and quality of life ($p < 0.05$). The Spearman correlation coefficient values, respectively, between food consumption patterns and blood vitamin D levels, height, weight, leg length, and quality of life were; 0.404; 0.290; 0.369; 0.380; 0.321.

Conclusions: The food consumption patterns of children in the second growth spurt period need to be considered because they are associated with vitamin D levels, height, weight, and quality of life.

INTRODUCTION

Food provides energy and nutrients, which are essential to human health. Nowadays, other food compounds are increasingly being identified so that their health benefits are becoming better understood¹. Food consumption patterns change throughout life due to biological, social, and environmental factors². Dietary habits are formed at a young age and maintained throughout later life. Proper nutritional intake, in terms of quantity and type, dramatically influences the growth and development of children. Good eating habits need to be developed during childhood to improve short-term health and avoid carrying unhealthy habits into adulthood, which are also associated with adverse long-term health outcomes, such as the risk of stunting³. The life and health of people in populations vary according to socioeconomic conditions, especially children who are vulnerable to the influence of various social, psychological, environmental, and family determinants⁴⁻⁶.

General self-health in children is reported to be associated with increased access to food and medical health care, education, safe drinking water, and household income⁷. Three meals a day is associated with happiness, positive self-assessment among vulnerable children, good relationships with parents or caregivers, and positive societal attitudes toward children⁸. In addition, "living with a mother" contributes to the frequency of carbohydrate-rich foods as a staple food⁹.

In 2013 a study was conducted on children under five years of age. An estimated 161.5 million children were stunted, 50.8 million had low birth weight (LBW) on the index weight/height z-score (WHZ), and 41.7 million were overweight or obese. Hence, the relationship between nutrition and growth in children is essential, especially regarding the relationship that will be conveyed, whether significant or not, among specific nutrients, weight, height, or Body Mass Index (BMI). Estimated average daily requirements should be covered

to have sufficient child growth. Carbohydrates are the primary energy source and play a key role in maintaining body weight. Besides, vitamin D, magnesium, calcium, and phosphorus are essential in height growth¹⁰. Grains, fruits, vegetables, and legumes are sources of carbohydrate-containing intake. Therefore, food is vital in supporting children's growth and development. In addition, fruit and vegetable intake helps prevent weight gain but helps reduce the risk of obesity^{11,12}. Only consuming high amounts of carbohydrates can increase the risk of insulin resistance in children and cause obesity in children¹³.

According to WHO, malnutrition in children has a 5-20 times greater risk of death than in children with good nutrition. As many as 54% of infant and child deaths are caused by malnutrition. Meanwhile, research results in Indonesia show that malnutrition causes 80% of child deaths¹⁴. Based on the 2001 National Health Survey (SURKESNAS), physical disorders experienced by toddlers in Indonesia reached a prevalence of 69.8%, while in Central Java, physical disorders were 27.23%¹⁵. Meanwhile, according to the 2018 Basic Health Research (Riskesmas), the nutritional status of children aged 5-12 years is normal at 69.15% for boys and 73.60% for girls in Central Java¹⁶. At the same time, previous research stated that 35.7% of children with malnutrition had a good quality of life, and 64.3% had a poor quality of life¹⁷.

An assessment of food consumption patterns can be used to consider healthy food consumption. It considers the combination of foods consumed that affect weight, height, and leg length and has been increasingly used in addition to individual food intake data. The current literature is limited to providing indications that dietary quality is associated with child weight, height, and quality of life, although the theoretical patterns provided by national nutritional guidelines differ among countries. As a result, any significant association found using specific country-specific indices may not hold for other populations. Second, there is a lack of research investigating the relationship between food consumption patterns and children's quality of life.

This study aimed to determine whether higher child food frequency questionnaire (FFQ) scores in children in Semarang City, Central Java, aged 10-14 years who were in the second growth spurt period had an impact on children's vitamin D levels, increased height, weight, and quality of life. Many studies, mostly from developed countries, compare QoL between healthy children and children with chronic conditions¹⁸. Indonesia is a developing country, and the prevalence of acute illness and low birth weight is still high¹⁶. However, knowing the relationship between apparently healthy subjects and QoL is also important. This study aimed to evaluate PedsQoL in children aged 10-14 in the general population and its determinants.

The low nutritional status of children is a challenge in developing countries and people with middle to lower socioeconomic status¹⁹. On the other hand, child obesity and the prevalence of overweight are global public health problems, even in high populations in developing and industrialized countries²⁰. There are several studies regarding the link between anthropometric measurements, food consumption, and

quality of life among older children globally and in Indonesia. This study assessed the relationship between food consumption patterns and height, weight, and quality of life among school-age children in Semarang, Indonesia.

METHODS

An observational study with a cross-sectional design was conducted in November-December, using 40 subjects, 23 from the Kun As Salam Sentono Islamic boarding school and 17 from MI At-Taqwa. The inclusion criteria were children aged 10-14 years who were healthy and had no physical disabilities.

All subjects who agreed would then have their serum vitamin D (25[OH]D) levels measured by taking a blood sample from a vein using the CMA (chemiluminescence microparticle immunoassay) examination method at the Paramita Clinical Laboratory Semarang. Furthermore, height was measured using a stadiometer, weight using a scale, and leg length using a caliper. An interview with parents using Food Frequency Questionnaire (FFQ) was done to measure children's food consumption patterns. The subjects were also assessed for quality of life using the Pediatrics Quality of Life Inventory instrument for ages 5-18 years (PedsQL). The PedsQL Questionnaire created by Dr. James Varni consists of 23 questions of 4 dimensions: physical activity, mental feelings, social and environment, and school. The PedsQL Questionnaire consists of 4 Likert scale answers: "Never" with a score of 100, "Rarely" with a score of 75, "Sometimes" with a score of 50, "Often" with a score of 25, and answer "Almost always happens" with score 0²¹. Then the FFQ questionnaire instrument was carried out to measure the subject's consumption patterns which consisted of 68 food items grouped into staple food groups consisting of rice, corn, cassava, sago, potatoes, bread; animal side dishes consisting of beef, sausage, shrimp, squid, crab, milkfish, snapper, chicken, chicken liver, chicken eggs, duck eggs, quail eggs, eel, salted fish and dried fish; vegetable side dishes consisting of green beans, soybeans, red beans, cashews, petai, tofu, tempeh, peanuts; vegetable A consisting of squash, lettuce, ear mushroom, radish, squash, cucumber, green onion, water gourd and watercress; vegetable B consisting of spinach, winged bean leaves, papaya, mustard greens, eggplant, chayote, carrot, cabbage, pumpkin, broccoli, green beans, bean leaves, bitter melon and bamboo shoots; vegetable C consisting of red spinach, cassava leaves, katuk leaves, mlinjo leaves, young jackfruit and papaya leaves; as well as fruits consisting of avocado, poor apple, dukuh, water guava, guava bol, arrowroot orange, kedondong, manga, melon and passion fruit. Food consumption score was categorized into six groups: "more than three times a day" was 50, "once a day" was 25, "3-6 times a week" was 15, "1-2 times a week" was 10, "2 times a month" was 5, and "never" was 0. The scores were then analyzed using the Spearman-Rho Correlation test²². Research ethical eligibility was approved by the Medical/Health Research Bioethics Commission, Faculty of Medicine, Sultan Agung Islamic University Semarang (No. 428/XII/2021/Commission on Bioethics).

RESULTS AND DISCUSSION

Table 1 shows that the majority of subjects were female. The subjects with normal BMI were 22.5%,

subjects who had sufficient vitamin D were 7.5%, and the majority of subjects had more than four family members.

Table 1. Subject socio-demographic analysis

Items	n	%
Gender		
Female	23	57.5
Male	17	42.5
Age		
10 years	18	45
11 years old	16	40
12 years old	6	15
Body mass index (BMI) ¹		
< 18.5 (underweight)	26	65
18.5-22.9 (normal)	9	22.5
23-24.9 (overweight)	5	12.5
Examination of vitamin D (25-(OH) D serum)		
Sufficiency	3	7.5
Insufficiency	14	35
Deficiency	23	57.5
Number of family members		
1-3	5	12.5
>4	35	87.5

Table 2. Variable mean results and Spearman correlation values

Variable	Means± SD	Correlation coefficient value (r) Spearman rho					p-value
		Vit D	Height	Weight	Leg length	quality of life	
Food consumption patterns	303.81 ± 47.40	0.404**	0.290*	0.369*	0.386*	0.321*	<0.05*
Vitamin D levels	19.65 ± 5.96	1	0.430**	0.317*	0.210*	0.175*	
Height	140.05 ± 7.09	0.430**	1	0.513*	0.567**	0.105*	<0.05*
Weight	35.39 ± 9.03	0.317*	0.513*	1	0.205*	0.223*	<0.05*
Leg length	35.71 ± 2.39	0.210*	0.567**	0.205*	1	0.351*	<0.05*
Quality of Life	1327.38 ± 134.14	0.175*	0.105*	0.223*	0.351*	1	<0.05*

Table 2 shows that the pattern of food consumption had a significant relationship with the height of r=0.290 and the same signification result for body weight, leg length, and QoL (0.369, 0.386, and 0.321 (p-value <0.05), respectively). Food consumption patterns showed that most subjects consumed more than six healthy foods. The average height of the subjects was 140.05 ± 7.09 cm, ideal for subjects aged 10-14 years²³. The mean vitamin D (25-(OH) D) serum level was 19.65 ± 5.96 µg/mL. These results showed that subjects' average vitamin D insufficiency was below 20 µg/mL. Then the average subject's weight was 35.39 ± 9.03 kg, ideal for children aged 10-14 with a height of 140 cm. The relationship between food consumption patterns and blood levels of Vit D showed a value of r= 0.404 with a p-value <0.01, and the relationship between blood vitamin D levels and quality of life was 0.175*. Similar to the

previous finding, vitamin D has a weak positive correlation with the quality of life of subjects (children aged 10-14 years who suffer from osteoarthritis)²⁴. Muscle weakness is another physiological explanation for the association between vitamin D deficiency and impaired quality of life. Several studies have shown that vitamin D supplementation reduces the risk of falls and fractures. Muscle weakness is a well-known risk factor for reduced quality of life in an older population with and without knee osteoarthritis^{25,26}. Physiological mechanisms may explain the association between vitamin D deficiency and poor quality of life with disturbances of normal activities related to cognitive function. A recent study revealed that vitamin D levels are associated with cognitive function, an essential factor affecting the quality of life in older people with chronic conditions²⁶.

Table 3. PedsQL questionnaire response analysis

Items	Never	Rarely	Sometimes	Often	Almost always
Physical dimensions	46.00%	42.26%	9.52%	1.78%	0%
Mental dimension	48.57%	21.90%	27.61%	10.50%	0%
Social dimension	45.71%	33.33%	20.00%	10.50%	0%
School dimension	18.09%	46.03%	19.04%	1.58%	0.79%

Of the 40 subjects analyzed, socio-demographic factors are listed in Table 1. The bivariate correlation analysis in Table 2 shows a positive correlation between height, weight, and consumption patterns on quality of life (p-value <0.05). These findings indicate that height, weight, and consumption patterns positively affect children's quality of life. In other words, the better the children's height, weight, and consumption patterns, the better the children's quality of life. The mean value shows that the average subject had a height of 140 cm, a body weight of 35.39 kg, and a leg length of 35.71 cm. The disturbances in the quality of life, including physical, mental, social, and school dimensions, were shown in the answers. The subject never had any disturbances (as many as 46%, 48.57%, 47.71%, and 18.09%, respectively).

Several studies have examined the relationship between childhood nutrition and the average child's foot length. In a non-randomized trial conducted in England in the 1930s, dietary supplements given to children aged 2–14 years over one year were associated with a 3.7 mm increase in height compared to controls²⁷. Most of the increase in height occurs from an increase in leg length (3.3 mm), specifically crest height (the distance from the floor to the top of the iliac crest measured with steel tape). However, because of the difficulty in accurately measuring the height of the crista, in subgroup analyses, the increase in leg length greater than overall height

would be less accurate²⁷. As shown in the correlation results, there was a significant relationship between leg length and height with a moderate correlation value of 0.567** because almost all of the increase in height occurs in the torso area, with little change in the relative proportions the leg or lower leg length. There was no disproportionate increase in the lower limbs in human growth for the effects of nutrition in pregnancy and early childhood²⁷.

The analysis of Vitamin D levels from 40 subjects showed an average of 19.65± 5.96 µg/mL, with 7.5% of subjects having vitamin D deficiency (above 20 µg/mL), 35% of subjects having vitamin D insufficiency (21-29 µg/mL), and 57.5% of subjects having vitamin D insufficiency (below 20 µg/mL). Lack of sun exposure and inadequate intake of vitamin D-rich foods, such as eggs, fish, liver, and milk, can cause low serum levels of vitamin D in the blood. The FFQ analysis showed that the low intake of animal sources such as meat, fish, and vegetables in children was caused by a dislike of taste and the relatively high price of fish²⁸. Data (25-(OH)D serum showed that most children had vitamin D deficiency of 57.5%. Several biological and demographic factors related to vitamin C supplementation, including baseline 25(OH)D, age, BMI or body fat percentage, ethnicity, and calcium intake, have been studied²⁸.

Table 4. FFQ questionnaire response analysis

Items	Means±SD
Staple food	
Rice	50.00 ± 0.00
Corn	4.13 ± 1.92
Cassava	8.13 ± 2.92
Potato	11.25 ± 5.63
Bread	12.25 ± 3.19
Animal side dishes	
Beef	1.25 ± 2.19
Sausage	9.25 ± 3.49
Shrimp	5.50 ± 2.72
Squid	4.88 ± 1.78
Milkfish	5.37 ± 2.86
Chicken	6.50 ± 4.55
Chicken's liver	5.12 ± 4.00
Chicken eggs	13.87 ± 3.83
Salted fish	4.50 ± 2.48
Dry fish	0.37 ± 1.33
Vegetable side dishes	
Mung beans	3.50 ± 2.58
Petai	2.00 ± 2.48
Tofu	16.63 ± 4.44
Tempeh	11.50 ± 5.21
Peanuts	4.88 ± 4.15
A vegetable	

Items	Means±SD
Gambas	8.37 ± 2.86
Lettuce	6.88 ± 4.48
Mushroom	3.37 ± 2.37
Cucumber	8.37 ± 3.27
Leek	9.38 ± 2.57
Watercress	3.50 ± 2.32
Water flask	3.37 ± 2.37
B vegetables	
Spinach	7.50 ± 4.93
Winged bean leaves	2.88 ± 2.50
Pawpaw	4.88 ± 3.66
Eggplant	6.13 ± 3.48
Chayote	4.13 ± 2.74
Carrot	6.50 ± 4.55
Cabbage	6.75 ± 4.16
Broccoli	5.63 ± 1.67
Beans	0.88 ± 2.74
Bamboo shoots	3.25 ± 2.66
C vegetables	
Red Spinach	0.50±1.51
Cassava leaves	2.63±2.52
Katuk leaves	0.25±1.58
Young jackfruit	3.25±2.66
Fruits	
Avocado	2.75 ± 3.19
Apple	3.25 ± 3.49
Hamlet	1.63 ± 2.37
Water apple	1.87 ± 2.45
Kedondong	0.13 ± 0.79
Mango	6.13 ± 4.15
Melon	5.88 ± 11.03

Previous studies have shown that the number of children in a household is related to stunting^{29,30}, but no difference was observed in this study. Although some participants reported living in homes with many children, >75% of participants lived with three or fewer children in this study. Hence, the number of children in the household did not affect children's food consumption or anthropometric measurements. When the need for carbohydrate-rich foods was adequate, it was estimated that children could consume quality foods such as protein-rich foods, although further research is needed to clarify the relationship between children's QoL and consumption of quality foods. Since carbohydrate-rich foods, including bread, rice, and cassava, are usually staple foods in the study area, they tend to be the first food choice. On the other hand, there was no clear distinction in the quality of food consumption, such as protein-rich foods, between children living with or without parents, although previous studies have shown that food security depends on the economic status of the household^{31,32} (which is related to the present and the support of father in the household)³³. The prevalence of underweight in children aged <10 years in a previous study in 2011 was 19.5%³³. A similar result related to the underweight prevalence was 65%.

Vitamin D obtained from food or UVB-induced conversion of 7-dehydrocholesterol in the skin undergoes enzymatic hydroxylation (25-hydroxylase) in the liver to form 25(OH)D³⁴. The metabolite 25(OH)D is the primary circulating form of vitamin D and is metabolically inactive

until it is converted to 1,25-dihydroxy vitamin D [1,25(OH)2D] via an enzymatic hydroxylation process (25-hydroxyvitamin D-1 α -hydroxylase)³⁵. The active metabolite, 1,25(OH)2D, which acts via the vitamin D receptor (VDR), can produce a variety of skeletal and non-skeletal effects^{36,37}. 1,25(OH)2D synergizes with parathyroid hormone (PTH) and modulates calcium homeostasis and bone metabolism. 1,25(OH)2D increases serum calcium concentration by increasing bone calcium mobilization, renal calcium reabsorption, and intestinal calcium absorption^{28,38}. Therefore, the amount consumption of foods containing vitamin D can have a positive effect on bone growth, especially when consumed by children. In this study, it can be observed that the leg length varies depending on the height and pattern of food intake. A deficiency of vitamin D experienced by subjects was a predictor of food consumption patterns that were less than optimal and had a weak positive relationship with the quality of life of children with a p-value= 0.321*. Quality of life consists of 4 dimensions closely related to environmental conditions and family³⁹. In filling out the PedsQL and FFQ questionnaires, the subject was assisted by his mother or guardian. Table 3 shows that most subjects do not feel any obstacles or limitations in the social, physical, mental, and emotional fields, as well as self-confidence; although some complain about obstacles in school studies and homework, it does not hinder other dimensions of quality of life. This result was consistent with previous research

that nutritional status significantly affects the QoL of school-age children 0.465 (p-value <0.001)⁴⁰.

The validity test of the Indonesian version of the PedsQL Questionnaire using the Pearson product-moment and the reliability using Cronbach alpha against the Indonesian version of PedsQL had been carried out previously, with an internal consistency value of 0.7 so that it was reliable and acceptable for broader use in this study⁴¹. Then, the statistical test found that the data were not normally distributed and homogeneous, so the correlation analysis used Spearman's non-parametric bivariate analysis. There was a positive correlation between each variable. The findings showed that a good food consumption pattern was significantly associated with leg length and height (p-value <0.05). Based on previous research, it is also known that the intake of calcium, vitamin D, magnesium, and phosphorus such as milk, oranges, broccoli, eggs, and chicken liver are several factors related to growth and bone density with a p-value <0.01⁴². The average score of family consumption patterns is included in the high category by consuming six or more food sources that are different from one another⁴³. Then in filling out the PedsQL Questionnaire, the children were accompanied by their mother or guardian in filling it out to provide valid answers to the condition of the subject.

In the FFQ analysis of food consumption patterns, all subjects can see the staple food consumption. Rice was indicated by an average score of 50, meaning the frequency of consuming rice was three times a day. The average consumption of corn was 40 subjects (twice a month). From an average score of 4.13 ± 1.924 , the average consumption of cassava, potatoes, and bread was 1 to 2 times a week. In consuming animal side dishes, most subjects consumed chicken eggs and sausages 3 to 6 times a week and 1 to 2 times a week. Then the average consumption of vegetable side dishes of green beans, peanuts, and bananas was twice a month, tofu and tempeh were 3-6 times a week, vegetable ear mushrooms, watercress, water gourd, winged bean leaves, chayote, papaya, bamboo shoots, cassava leaves, broccoli, and young jackfruit was twice a month, and the subjects never ate red spinach, beans, and katuk leaves. Then on average, the subjects consumed lettuce, cucumber, squash, leek, spinach, eggplant, carrot, and cabbage 1-2 times a week. Mangoes and melons were the most frequently consumed by the subjects (1-2 times a week), and avocados, apples, dukuh, guava, and kedondong were consumed twice a month. These results follow previous research that food consumption preferences in children vary greatly depending on taste preferences, environment, parents' food habits, and body condition. Then mangoes and melons were the most frequently consumed by the subjects, namely 1-2 times a week, then avocados, apples, dukuh, guava, and kedondong were consumed every two times a month. This result follows previous research, food consumption preferences in children vary greatly depending on taste preferences, environment, parents' food habits, and body condition⁴⁴.

Strategies to improve healthy eating behavior in children can be done by providing healthy food at home, avoiding unhealthy places to eat and fast food, avoiding

using food rewards, serving moderate portions, helping manage the eating environment, and encouraging children to try new things foods. As children's role models, parents should eat healthy and enjoyable food. Parents should not show food aversion in front of children. They should repeatedly expose children to healthy food, allow children to have input in food choices, provide a high frequency of family meals and feeding suggestions, empower people aging, provide social support, family environment, availability of healthy food, reduce screen time and get enough sleep⁴⁵⁻⁴⁷. In line with previous findings, the average height of children who eat vegetables daily is lower height⁴⁸. In previous studies regarding carbohydrate intake, it was negatively correlated with body weight and height, which means that carbohydrate intake did not affect body weight and height⁴⁹. In this study, it was the same with food consumption patterns, both in terms of carbohydrates from staple foods, fruit, nuts, and meat, which have a weak positive correlation with body weight and height, which are physiological factors of body metabolism and physical activity of the respondents can cause. However, high fiber intake for children aged 10-12 years should consume >26 grams of fiber/day does not affect children's growth and is strongly associated with a reduced risk of obesity, especially when consumed in the form of fruits, vegetables, nuts, and whole grains⁵⁰.

The limitation of this study was that the parents of children participating in it did not fill in their data entirely. This difference in response rates may represent parental bias in terms of estimates of quality of life and a slightly exaggerated pattern of food consumption for children, most of whom are deficient in vitamin D. This research also has some limitations. Only the number of meals per day and the variation in consumption of carbohydrate-rich and protein-rich foods were assessed, while food quantity and nutrient intake were not included. The authors did not evaluate the consumption of tea, milk, and/or other beverages containing sugar because this study aimed to evaluate the relationship between factors related to anthropometric measurements such as height, weight, leg length, then food consumption, and QoL in general in Semarang, not to assess the details of growth monitoring in young school children through multi-dimensional measurements. Because this study has a cross-sectional design, it was impossible to evaluate the long-term influence and food consumption on children's growth and anthropometric measurements to determine the relationship between these factors and children's self-assessment QoL.

CONCLUSIONS

This study concludes that there was a positive relationship between food consumption patterns on height, weight, limb length, quality of life, and blood levels of vitamin D, as indicated by the Spearman correlation coefficient. The quality of children's lives in the physical, mental, social, and school dimensions is in a suitable category, indicated by the frequency of the answers "never had any obstacles and "rarely had any obstacles," being the majority of the answers.

ACKNOWLEDGEMENTS

Thanks to the Ministry of Education and Culture and Research and Technology for the 2021 PTUPT grant, Pondok Kun Assalam Sentono, and MI At-Taqwa.

Conflict of Interest and Funding Disclosures

All authors have no conflict of interest in this article. This research was funded by the Ministry of Education and Culture Research and Technology through PTUPT grants in 2021

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