



NUTRITIONAL ADEQUACY, PHYSICAL ACTIVITY, AND DIARRHEA HISTORY IN RELATION TO INTELLECTUAL INTELLIGENCE AMONG BOYS

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Abstract

Intellectual development in school-aged children was influenced by nutritional adequacy, physical activity, and health history, yet limited studies explored their combined impact in Indonesian primary school settings. This study investigated relationships between nutritional adequacy, physical activity, diarrhea history, and intellectual intelligence levels among 41 male elementary students aged 9-12 years at SDN 04 Bojongsari Depok. Male participants were specifically selected to reduce variability related to sex differences, as boys generally demonstrate higher physical activity levels, greater nutritional requirements, and a higher incidence of diarrhea compared to girls. Samples selected via stratified random sampling based on grade level. The relatively small sample size was due to the limited number of eligible participants who met the inclusion criteria during the study period. Nutritional adequacy was assessed using the Semi-Quantitative Food Frequency Questionnaire (SQFFQ) for macro- and micronutrients, physical activity via the Physical Activity Questionnaire for Children (PAQC), each questionnaire was measured using the Indonesian version and has been commonly used among Indonesian school-aged children to estimate dietary intake. Diarrhea history through a researcher-designed questionnaire, consisting of items related to the frequency and duration of diarrhea episodes during the previous one year. All items were declared valid, with r-table value of 0.3081. Reliability testing showed a Cronbach's alpha coefficient of 0.896, indicating excellent internal consistency. Intellectual intelligence was assessed using the Indonesian version of the Culture Fair Intelligent Test (CFIT). The test was administered by a trained psychologist following standardized testing procedures. Data analysis employed Spearman correlation tests with significance at $p < 0.05$. No significant relationships were found between macronutrient adequacy ($p = 0.953$, $r = +0.010$), micronutrient adequacy ($p = 0.133$, $r = +0.239$), physical activity ($p = 0.625$, $r = +0.079$), or diarrhea history ($p = 0.650$, $r = -0.073$) and intellectual ability. The observed correlations were weak, suggesting minimal practical influence of these variables on intellectual ability in this study population. Nevertheless, the findings should be interpreted cautiously, as other factors such as learning environment and socioeconomic status were not evaluated.

Keywords: *Nutritional Adequacy ; Physical Activity ; Diarrhea History ; Intellectual Intelligence ; School Children*

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1. Introduction

In achieving a nation's progress, the quality of the next generation largely depends on children's intelligence and education (Kinanti & Trihantoyo, 2021). In Indonesia, the quality of education and the level of intelligence in children still face challenges. Based on the 2025 International IQ Test data, Indonesia ranked 98th with an average score of 93.18, below the global average score of 100. This is further evidenced by the results of the Programme for International Student Assessment (PISA), a survey that measures student literacy, in which Indonesia ranked 70th out of 80 countries. These findings suggest that literacy, comprehension, and higher-order thinking skills among school-aged children may still require further improvement.

In addition, the Human Development Index (HDI) for education in West Java Province was reported to be 73.74, and in Depok City reached 83.05 as of 2024, indicating a better quality of education compared to other cities in West Java. However, Bojongsari District has a lower quality of life, ranking among the three districts with the lowest values in Depok City, with an HDI of 79.23, indicating disparities in quality of life and brain developmental among children. During childhood, the brain exhibits high plasticity, allowing adaptation to environmental and educational stimulation. Therefore, various health-related factors during school age may substantially influence children's cognitive development and intellectual ability. Brain development occurs through stages of neural cell proliferation, cell differentiation, myelination, and synapse formation, which are important in determining learning capacity and cognitive development. During childhood, the brain has high plasticity, allowing for adaptation to various learning environments. A lack of educational stimulation during childhood may trigger structural changes in brain areas involved in logical processing, thereby impacting academic abilities (Ariani & Khudri, 2025). Children's cognitive development is also related to health conditions, including nutritional adequacy, physical activity levels, and history of infectious diseases. Nutritional adequacy is a crucial component of children's physical and brain growth and development.

Nutritional adequacy is an important component in the growth and development of children's bodies and brains. (Buanasita et al., 2015). In addition to macronutrients, micronutrients such as vitamin B6 and iron play significant roles in brain cell development and enhancing cognitive function (Irawan, 2020). According to the Ministry of Health, 17.7% of children in Indonesia suffered from malnutrition in 2018 (Aulia, 2022). Furthermore, 28.1% of children aged 5-12 years experienced iron deficiency (Prasetiani & Ludong, 2023), and 18.2% of elementary school children lacked vitamin B6 (Supriadi et al., 2022). Children's nutrient intake can be measured using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), which assesses the frequency and quantity of food consumption over a certain period, providing an overview of daily nutrient adequacy (Ardiyanti & Diana, 2025).

In addition to nutrition, physical activity has a positive impact on cognitive development, such as concentration and thinking processes. The 2018 Riskesdas results indicated that 64.4% of individuals in Indonesia aged 10-14 were categorized as insufficiently active. Children's physical activity is generally assessed using the Physical Activity Questionnaire for Children (PAQ-C), an instrument that evaluates physical activity over the past seven days in elementary school-aged children (Anggraini et al., 2025).

A history of infectious diseases, such as diarrhea, is a common health problem in developing countries, especially among children (Iqbal et al., 2022). Diarrhea affects nutrient absorption essential for children's growth and development and is a leading cause of malnutrition in school-aged children (Iqbal et al., 2022). The prevalence of diarrhea among school children in West Java is among the ten provinces with the highest number of diarrhea cases in Indonesia (Azizah et al., 2024). Children's history of diarrhea can be identified through a diarrhea history questionnaire, which includes frequency, duration, and symptoms experienced.

On the other hand, boys tend to be more physically active, thus requiring higher nutrient intake (Yastirin et al., 2022). Higher physical activity is also associated with a greater risk of diarrhea in boys (Situmeang, 2024). This condition is important to note because children aged 9-12 years are in an important stage of cognitive and logical development, during which they begin to apply logical thinking processes before the development of more advanced abstract reasoning at older ages (Anditiasari & Dewi, 2021; Suryana et al., 2022). Research exploring how these factors relate to intellectual intelligence levels in boys in Bojongsari, Depok, is still limited. Therefore, this study aimed to analyze the relationship between nutritional adequacy, physical activity, and diarrhea history with intellectual intelligence among boys aged 9-12 years at SDN 04 Bojongsari, Depok City. We hypothesized that nutritional adequacy and

physical activity would be positively associated with intellectual ability, while diarrhea history would be negatively associated.

2. Method

This observational quantitative study used a cross-sectional design and was conducted in a single elementary school, which may limit the generalizability of the findings to other populations. Conducted at SDN 04 Bojongsari, Depok City, from September to October 2025. The research subjects were male students in grades 4-6 who met the inclusion criteria (aged 9-12 years, physically and psychologically healthy, and willing to participate in the IQ test) and did not meet the exclusion criteria (having developmental disorders or neurological abnormalities, chronic diseases/congenital conditions affecting nutrition, or currently undergoing a special diet). Written informed consent was obtained from parents prior to data collection, and written assent was obtained from all participating children. .

Sampling was performed using a proportional stratified random sampling technique based on grade level (grades 4-6). The minimum sample size was estimated based on previous related studies, with an additional 10% added to anticipate potential dropout during data collection. A total of 41 eligible male students aged 9-12 years participated in the study. Proportional allocation resulted in 15 students from grade 4, 15 students from grade 5, and 11 students from grade 6. . During data collection, the total number of respondents was 41 students, all of whom were included in the study.

$$n = \frac{\left\{ Z_{1-\alpha/2} \sqrt{2P_2(1-P_2)} + Z_{1-\beta} \sqrt{P_1(1-P_1)} \right\}^2}{(P_1 - P_2)^2}$$

n : Required sample size
P₁ : Proportion in population 1
P₂ : Proportion in population 2
Z_{1-α} : Significance level
Z_{1-β} : Test power

Intellectual intelligence was measured using the Culture Fair Intelligence Test (CFIT) scale 2 and classified into low IQ and normal IQ. Raw scores were converted into IQ categories and classified as low IQ (<90) and normal IQ (≥90). The examiners were blinded to the participants nutritional adequacy, physical activity, and diarrhea history data. Nutritional adequacy was assessed using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) which evaluated macronutrient intake (carbohydrates, protein, and fat) and micronutrient intake (vitamin B6 and iron). Dietary intake data were compared with the Indonesian Angka Kecukupan Gizi (AKG) based on the Ministry of Health Regulation No. 28 of 2019. Nutrient adequacy levels were categorized as low, adequate, or high for macronutrients and as low or adequate for micronutrients. , then categorized as low, adequate, or high for macronutrients and as low or adequate for micronutrients. Physical activity was measured using the Physical Activity Questionnaire for Children (PAQ-C) and categorized as low or adequate based on the median value, while a history of diarrhea was assessed through researcher-developed questionnaire adapted from previous literature and the criteria from Perkumpulan Gastroenterologi, Hepatologi, dan Nutrisi Anak Indonesia (PGHNAI), which included questions regarding the occurrence and duration of diarrhea within the past month and categorized as no diarrhea, acute diarrhea, or prolonged/recurrent diarrhea. The questionnaire demonstrated acceptable validity and excellent reliability, with item validity coefficients ranging from 0.649-0.874 and a Cronbach's alpha coefficient of 0.896. All history data were collected using self-reported questionnaires and may therefore be subject to recall bias.

Data collection was conducted at SDN 04 Bojongsari, Depok City, through the completion of the SQ-FFQ, PAQ-C, and diarrhea history questionnaires, followed by the administration of the CFIT IQ test. The collected data underwent editing, coding, entry, and cleaning before analysis. Bivariate analysis in this study was performed using the Spearman correlation test because several variables were ordinaly categorized. Relationships between variables were considered statistically significant at p < 0.05. Correlation strength was interpreted as weak (|r| < 0.30), moderate (|r| = 0.30-0.49), or strong (|r| ≥ 0.50). Statistical analysis was conducted using SPSS version 24. Multivariable adjustment was not performed because the study primarily aimed to explore bivariate relationships among variables within a relatively small sample size. The strength of the relationship between two variables was determined based

on the Spearman correlation coefficient obtained. This study was approved by the Ethics Committee of UPN Veteran Jakarta on August 22, 2025, with ethical approval number 165/VIII/2025/KEP.

3. Result and Discussion

Table 1 summarizes the characteristics of the study participants and the distribution of the main study variables among 41 male students at SDN 04 Bojongsari. Overall, most participants demonstrated adequate macronutrient & micronutrient intake and relatively good physical activity levels. In contrast, prolonged or recurrent diarrhea was reported in only a small proportion of participants. Intellectual quotient (IQ) scores were generally distributed within the borderline to average categories.

Table 1. Characteristics and Overview of Study Variables in Male Students at SDN 04 Bojongsari

Variable	Frequency (n)	Percentage (%)
Age		
9 years	4	9.8%
10 years	17	41.5%
11 years	10	24.4%
12 years	10	24.4%
Mean $\pm$ SD	10.6 $\pm$ 0.9 years	
Grade		
Grade 4	15	36.6%
Grade 5	15	36.6%
Grade 6	11	26.8%
Nutritional adequacy		
Macronutrients		
Low	5	12.2%
High	24	58.5%
Adequate	12	29.3%
Micronutrients		
Low	1	2.4%
Adequate	40	96.4%
Physical Activity		
Low	18	43.9%
Adequate	23	56.1%
History of Diarrhea		
No diarrhea	19	46.3%
Acute diarrhea	19	46.3%
Prolonged/recurrent diarrhea	3	7.3%
Tingkat IQ		
Mentally Defective	7	17.1%
Borderline	17	22%
Low average	8	19.5%
Average	17	41.5%
High Average	0	0.0%
Superior	0	0.0%
Very Superior	0	0.0%
Genius	0	0.0%

Table 2 presents the results of the analysis of the relationship between independent variables and intellectual intelligence levels. No significant relationships were found between macronutrient adequacy, micronutrient adequacy, physical activity, and history of diarrhea with intellectual intelligence ($p = 0,953$; $p = 0,133$; $p = 0,625$; and $p = 0,650$), with Spearman correlation coefficients ($r = +0,010$; $r = +0,239$; $r = +0,079$; $r = -0,073$) indicating a very weak to weak strength of association. The direction of the relationship was

positive (direct) for nutritional adequacy and physical activity, and negative (inverse) for history of diarrhea.

Table 2. The Relationship of Nutritional Adequacy, Physical Activity, and History of Diarrhea with Intellectual Intelligence

Variable	IQ Level	
	p	r
Macronutrient Adequacy	0.953	0.010
Micronutrient Adequacy	0.133	0.239
Physical Activity	0.625	0.079
History of Diarrhea	0.650	-0.073

3.1 Macronutrient Adequacy

This study found no significant relationship between macronutrient adequacy and intellectual intelligence among male elementary school students ($p = 0.953$; $r = 0.010$), indicating a very weak positive correlation. These findings suggest that macronutrient adequacy may have limited influence on intellectual intelligence within this study population. These findings are consistent with Mawarni (2020), who reported no significant relationship between protein intake and students academic achievement ($p = 0.704$). Academic achievement reflects intellectual intelligence, as comprehension and critical thinking demonstrate cognitive ability. Mawarni (2020), suggested that the lack of association may be influenced by unmeasured factors such as parenting style and genetic factors, which contribute to children's intelligence capacity. Similarly, Ayatasya et al., (2017), reported no significant relationship between energy ($p = 0.710$), carbohydrate ($p = 0.948$), protein ($p = 0.068$), or fat ($p = 0.105$) intake from breakfast and cognitive performance, suggesting that variation in types of foods consumed may influence the results.

Theoretically, balanced intake of carbohydrates, protein, and fat provides energy and essential substrates for brain function, supporting thinking, concentration, and intellectual achievement. However, this study did not find a significant association. Balanced nutrient intake helps improve learning concentration, supports the immune system, and prevents the risk of diseases related to nutrient deficiency or excess (Tika *et al.*, 2025). Based on a study conducted on 41 students, the majority had excessive nutrient intake, with 24 students (58.5%) falling into this category. This indicates that most students received macronutrients in amounts exceeding requirements, fulfilling their energy and nutrient needs, although guidance is still needed to ensure a more balanced composition according to dietary recommendations. Excess nutrient intake can result from children consuming two to three portions of side dishes and high-protein snacks, such as sausages and meatballs, as well as from fast food, foods high in saturated fat, and foods and beverages high in sugar. Another study by Nurhafiza *et al.* (2018) reported that 60% of male students had energy intake exceeding daily requirements. Daily energy is derived from the metabolism of protein, fat, and carbohydrates. However, it is important to guide intake to avoid excessive total energy, so that the benefits of protein for growth and cognitive function are optimized without leading to fat accumulation, which can affect brain function and, consequently, cognitive ability (Paramudhita, 2024).

Thus, while nutrient adequacy is crucial for supporting physical growth and health, this study showed no significant relationship between macronutrient adequacy and students intellectual intelligence. Other factors, such as parenting style and genetics, may influence brain structure formation and contribute approximately 30-50% to intelligence, with the remainder determined by environmental factors, including parental attention, learning stimulation at home and school, and family economic conditions that allow optimal learning experiences (Hayati & Martilova, 2021).

3.2 Micronutrients Adequacy

This study also found that micronutrient adequacy did not have a significant relationship with children's intellectual intelligence, as indicated by Spearman correlation ($p = 0.133$, $p > 0,05$). These results align with Ayatasya et al., (2017) who found no relationship between iron intake and academic achievement, and Handayani et al., (2020) who reported no association between vitamin intake and students academic performance. In contrast, studies by Widiani et al., (2024) and Azis & Hasanah, (2018) showed high prevalence of micronutrient deficiencies affecting cognitive function, suggesting that

differences in results may be influenced by nutrient adequacy within each population. Vitamin B6 plays a role in amino acid metabolism and neurotransmitter formation, which affects cognitive function, while iron is important for oxygen transport to brain tissue and myelination processes. Severe iron deficiency can cause cognitive impairment, but the weak correlation observed in this study was not statistically significant. Therefore, micronutrients play a role in supporting brain function; however, in this study, micronutrient adequacy did not significantly affect intellectual intelligence. This may be due to other unmeasured factors such as parenting, genetics, concentration, and environmental conditions.

3.3 Physical Activity

Spearman correlation analysis showed $p = 0.625$ ($> 0,05$), indicating no significant relationship between physical activity and intellectual intelligence. The correlation coefficient was $r = 0,079$, suggesting a positive trend, with higher activity tending to be associated with higher IQ, but the very weak correlation rendered the relationship statistically insignificant.

These findings are consistent with Suwandaru & Hidayat (2021) who found no significant relationship between physical activity and academic achievement, and Muhamad et al., (2025), who reported a negative relationship, possibly due to high physical activity reducing study time or causing physical and mental fatigue, impacting learning concentration. Reduced concentration can impair students understanding and information processing, which affects academic performance, a reflection of intellectual intelligence. Physical activity can support learning only when appropriately balanced in quality, duration, and type, alongside effective time management and a supportive learning environment (Muhamad et al., 2025).

Contrasting results by Runesi et al. (2024) and (Santoso & Anandaputra (2016) showed associations between physical activity and cognitive function. Physical activity can influence brain function by increasing blood and oxygen flow to the brain, which supports attention and information processing during learning (Agoes, 2024). In this study, most students had good physical activity levels, while a portion had low activity levels, indicating that although more than half of the students were physically active, some still had suboptimal activity. The differences in these study results indicate that the relationship between physical activity and intellectual intelligence is not always direct and can be influenced by various other factors. Therefore, although physical activity provides benefits for overall health, the findings of this study show that physical activity was not significantly associated with students intellectual intelligence at the study site.

3.4 Diarrhea History

In this study, most students had either acute diarrhea or no history of diarrhea, with a small proportion experiencing prolonged diarrhea. This aligns with Ibrahim (2021) and Hilmiah et al. (2022) who reported that most elementary school children experience no diarrhea or only acute diarrhea. The high number of children without diarrhea indicates relatively good health, likely supported by clean and healthy behavior and environmental factors such as sanitation and hygiene (Hadriani et al., 2024).

The results of this study showed no significant relationship between diarrhea history and students intellectual intelligence. Spearman correlation analysis indicated $p = 0,650$ ($p > 0,05$), with a correlation coefficient of $-0,073$. The negative correlation suggests that more severe episodes of diarrhea tended to be associated with lower IQ, but the relationship was very weak and not statistically significant. These findings are consistent with Nisa (2020) and (Nurhayati et al. (2022) who found no association between diarrhea history and growth disorders. In contrast, Solin et al. (2019) and (Hilmawati & Retnaningsih (2023) reported a link between diarrhea and stunting in young children. Children who experience stunting are at risk of cognitive impairment due to disrupted neural maturation, which affects brain structure and function (Dwi et al. 2019).

Growth inhibition due to infectious diseases in children is most often caused by diarrhea, leading to nutrient loss and impaired absorption in the intestines (Veri et al., 2025). Recurrent or prolonged diarrhea can cause malnutrition and protein-energy deficiency, affecting metabolism and reducing available energy for growth and brain development (Hadriani et al., 2024), potentially impacting cognitive function. Prolonged diarrhea lasting more than two weeks can cause malabsorption and nutrient loss, which is indicated by weight loss (Juliansya et al., 2021). Weight loss reflects disrupted nutrient intake and absorption, which play a role in cognitive development, potentially inhibiting children's physical growth and cognitive function (Azizah & Rizana, 2023). However, in this study, only a small number of children

experienced weight loss due to prolonged diarrhea, suggesting that long-term effects on intellectual intelligence are unlikely.

Therefore, although diarrhea physiologically has the potential to impair nutrient absorption critical for brain development, in this study, diarrhea history was not associated with students' intellectual intelligence. This indicates that other factors, such as genetics, health status, environment, and individual characteristics, also contribute to supporting children's intellectual capacity (Febrianti et al., 2025).

4. Conclusion and Suggestion

This study found no significant relationships between nutritional adequacy, physical activity, diarrhea history, and intellectual intelligence among male elementary school students. The observed correlations were generally very weak, suggesting limited influence of these factors on intellectual intelligence within the study population. For future studies, it is recommended to involve larger and more diverse populations, including both male and female students, to improve generalizability and statistical power. Longitudinal study designs and multivariable analyses are also recommended to better evaluate causal relationships and control for potential confounding factors such as socioeconomic status, parenting style, and learning environment.

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