



Association between nutritional status and physical activity level towards short-term memory ability in elementary school students

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ABSTRACT

Background: There is a process of growth and development in children, including the ability to remember information, which is an essential component of the learning process; this memory is regulated by nutritional status and the amount of physical activity. This study aims to determine the association between nutritional status and physical activity level on short-term memory skills in children aged 9-11 years at SD Negeri 5 Peguyangan.

Methods: The research method used a cross-sectional study design with a purposive sampling technique. The number of subjects obtained is sixty-eight subjects according to predetermined criteria at the 5th Elementary School of Peguyangan, Denpasar, Bali, Indonesia. Data were collected by calculating the body mass index to determine nutritional status and measuring the physical activity level by filling out the physical activity questionnaire for older

children (PAQ-C). The digit span test is used to assess short-term memory abilities. To find an association between nutritional status and physical activity level on short-term memory skills, data were analysed using SPSS 26.0.

Results: Based on Spearman's rho non-parametric analysis test, it was found that the relationship between nutritional status and short-term memory abilities obtained $p=0.006$ ($p < 0.05$) with $r=0.331$. In addition, the association between the physical activity level obtained a $p=0.000$ ($p < 0.05$) with $r=0.555$. This indicates an association between nutritional status and physical activity level in short-term memory abilities.

Conclusion: There is an association between nutritional status and physical activity level on short-term memory skills among elementary school students.

Keywords: body mass index, nutritional status, physical activity level, PAQ-C, short-term memory ability.

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INTRODUCTION

Human life cannot be separated from the process of learning and remembering.¹ Memory is a biological process that involves the entire coordination system, which works continuously and actively in order to be able to receive, store and recall information that has been obtained before.² Memory is useful for storing information that has been obtained from the learning process, which can be retrieved for use at some time in the future.¹

Short-term memory has an important role in thinking and problem-solving. Some of these problems will be stored in short-term memory, as well as accessing information related to existing problems from long-term memory. The activation degree of short-term memory can affect children's learning processes because it affects the speed of children's cognitive processes. Furthermore, short-term memory is used to stop before going to long-term memory.³

Several factors affect short-term memory, like nutritional status and physical activity level. One

of the factors that affect short-term memory is nutritional status. Nutritional status is important for every individual to know to anticipate and prevent malnutrition and excess nutrition.⁴ Nationally, the prevalence of nutritional status in children aged 6 to 12 years based on Riskesdas data in 2010, consists of the very thin category of 4.6%, the thin category of 7.6%, the normal category of 78.6% and the obese category 19.2%.⁵ Research by Sorrakalaya and Rao in 2017 states that from several test trials conducted, there was a low memory status in girls with obesity; girls who were not obese had a higher memory status. Less calorie consumption and eating a balanced diet may be an easier strategy to avoid memory loss as we get older. Excessive calorie intake may cause oxidative damage that causes structural changes in the brain.⁶ Nutritional imbalance can affect a person's memory ability after entering school, and it begins to decrease when entering adulthood.⁴

Another factor that affects short-term memory is physical activity. Physical activity is any form of body movement produced by skeletal muscles

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and resulting in significant energy. Physical fitness obtained from physical activity is very influential in work and study productivity because regular physical activity helps in thinking, learning, and making decisions. Based on Riskesdas data (2018), the proportion of Indonesian residents who do physical activity is 33.3%. Meanwhile, the proportion of Indonesians who behave casually, namely ≥ 6 hours per day, is 24.1%. Thus, the physical activity of the Indonesian population is still low. Research from Junaidi et al. showed that physical activity can improve memory ability because it increases neurotrophins, such as brain-derived neurotrophic factor (BDNF). BDNF neurotrophin can increase neuronal viability and brain plasticity, which are important in memory.⁷ Low physical activity will impact the occurrence of obesity in children, which causes concentration problems which can lead to decreased children's achievement at school.⁸

The researchers raised this topic because this research has not been widely conducted in Indonesia, especially in Bali. The researcher chose the 5th Elementary School of Peguyangan as the research location because they had never done a similar study before. In addition, based on the results of interviews with teachers at the school, there were difficulties in learning in class after the COVID-19 pandemic. This study is important to do considering the role of short-term memory is very important in children's future learning process. After the COVID-19 pandemic, many children behaved sedentary and paid little attention to nutrition and physical activity. Therefore, the author will raise this topic to know the association between nutritional status and physical activity level and short-term memory ability in children aged 9-11 at the 5th Elementary School of Peguyangan. This study aims to add insight and is expected to be able to determine appropriate preventive measures and interventions for children with abnormal nutritional status and low levels of physical activity to improve their short-term memory abilities.

METHODS

The research method is a cross-sectional study. In this cross-sectional study, researchers examined the relationship between the independent variable (risk factors) and the dependent variable (effect). Measurement of the variables is only done once. This study is taking place at the 5th Elementary School of Peguyangan on 14 and 24 of September 2022. The sample in this study was calculated using the statistical calculator (StatCalc) application. First, the researcher determined the population. Then from that population, 76 subjects were selected who

met the inclusion criteria. After the subjects were collected, samples were taken using a purposive sampling technique. From the subject-taking technique, 70 subjects were willing to participate in the study. However, because of the results of the sample formulation, 2 of the 70 subjects were the criteria for dropping out. The number of subjects obtained is 68 according to inclusion and exclusion criteria. The inclusion criteria are children aged 9-11 years who study at the 5th Elementary School of Peguyangan; the general condition is healthy based on vital sign check, cooperative and willing to participate in this research. The exclusion criteria are the history of head trauma, neurological disorders, history of epilepsy, intracranial infections, and abnormalities in the eyes and ears based on the results of interviews. Impaired motor function based on the results of physical examination and experiencing physical disabilities that can affect physical activity in children known through observation and interviews.

Measuring the nutritional status using body mass index (BMI) based on age by calculating weight and height. Participants will first be measured in their height and weight. Then the weight in kilograms will be divided by the height squared in meters. The result matched with the z-score table for children aged 5-11 years which exists in Minister of Health Regulations Number 2 in 2020. With the interpretation of undernutrition (range: -3 - -2 standard deviation of BMI), good nutrition (range: -2 - -1 standard deviation of BMI), overnutrition (range: $+1$ - $+2$ standard deviation of BMI), obesity ($> +2$ standard deviation of BMI).⁹

Assessing the physical activity level of children aged 8-14 using the physical activity questionnaire for older children (PAQ-C). The PAQ-C instrument is a self-reporting instrument that uses the previous 7 days' activities. The PAQ-C instrument provides a summary of the physical activity scores obtained from 9 items, where each score uses 5 points. Each item's scores will be added, and then the average will be sought. With the following interpretation: value 1 is very low, value 2 is low, value 3 is moderate, value 4 is high, and value 5 is very high. Previous studies showed that the PAQ-C instrument significantly correlates with the physical activity level instrument, translated into Indonesian. The same research also shows that the PAQ-C instrument is reliable, with a Cronbach Alpha score between 0.0682 – 0.745.¹⁰

The short-term memory ability is measured using a digit span test consisting of a digit span forward and a digit span backwards. The researcher carried out the span forward digit test, citing multiple digit numbers ranging from 3 to 9. Afterwards, the

child will be told to repeat the numbers provided by the researcher successively. For the digit span backward test, the researcher will mention several digit numbers starting from 3 digits up to 9 digits. After that, the child is instructed to repeat the list numbers mentioned sequentially from the end. The test will be stopped if the child fails to say the digits accurately. Interpretation of the digit span test results 15-19 means very good, 11-14 means good, 9-10 means average, 5-8 means low, and 0-4 means very low. The internal reliability of the digit span test is at a score of 0.70 to 0.90. This shows that the test has high internal reliability. Based on previous studies, the digit span backward test has good reliability and low validity.¹¹

The research begins by explaining the purpose and intent of the research to the subject and the subject's guardian. After that, the researcher will provide informed consent to the subject's guardian to be signed as proof that the subject's guardian authorized the subject to conduct this research. Subjects will first be selected by anamnesis with the subject's guardian and examination of vital signs. Then the subject will be measured for his height and weight. The research continued with the subject doing a digit span test. Finally, the researcher will fill out the PAQ-C questionnaire by interviewing the subject.

Statistical tests used in this study were univariate analysis and bivariate analysis using SPSS 26.0. Univariate analysis was conducted to see a general picture of age, gender, nutritional status, physical activity level and short-term memory abilities. Bivariate analysis was conducted to determine the

relationship between nutritional status and short-term memory abilities and between physical activity levels and short-term memory abilities. Bivariate analysis used Spearman's rho.

Researchers prepare before data collection and use equipment that is tested before use. This reduces the instrument's internal bias. When conducting interviews, the researcher can explain the real intent of the research and assure the subjects and guardians of the subjects interviewed that the information provided will be kept confidential. In addition, researchers seek conducive conditions in the room where the research is carried out.

RESULTS

Table 1 shows the characteristics of respondents, which contain personal data. Boys dominated the survey, with 36 (52.9%) of 68 youngsters participating. There were 15 children (22.1%) who were obese, 13 people (19.1%) who were overweight, and 40 children (58.8%) who had good nutritional status. In general, the physical activity level of students at the 5th Elementary School of Peguyangan is still low, with 39 students (57.4%), 19 students (27.9%) engaging in moderate levels of physical activity, and 10 students (14.7%) engaging in high levels of physical activity. The findings of the digit span test showed that 26 children (38.2%) and 42 children (61.8%) had average and low short-term memory skills, respectively.

Shown the data in Table 2, the Spearman rho test. The relationship test result with measuring nutritional status using body mass index based on age and instruments for short-term memory ability using the digit span test are correlated. Can be seen from the correlation coefficient of 0.331 and p -value=0.006. The relationship between nutritional status and short-term memory ability in 5th Elementary School of Peguyangan children showed a significant 2-tailed < 0.05 value. The value of closeness is low. This indicates by a correlation coefficient of 0.331. The coefficient correlation is positive, increasing nutritional status and short-term memory ability.

The relation between the physical activity level and short-term memory ability showed in Table 3. From the data of Spearman, the rho test can be concluded that physical activity level and short-term memory ability are correlated. The correlation coefficient is 0.555, and the p = 0.000. The relation between physical activity and short-term memory ability in children at the 5th Elementary School of Peguyangan can be known from the number value of significant 2-tailed less than 0.05. The correlation coefficient is 0.555, indicating that the value proximity is moderate.

Table 1. Characteristics of respondents

Characteristics	<i>n</i>	Percentage (%)
Age		
9	22	32,4
10	27	39,7
11	19	27,9
Gender		
Male	36	52,9
Female	32	47,1
Nutritional status		
Obese	15	22,1
Overweight	13	19,1
Normal	40	58,8
PAQ-C questionnaire		
Low	39	57,4
Moderate	19	27,9
High	10	14,7
Digit span test		
Low	42	61,8
Average	26	38,2

n, number of respondents.

Table 2. Cross table of nutritional status on short-term memory ability

Nutritional Status	Short-term Memory Ability						Correlation	P-value
	Low		Average		Total			
	n	%	n	%	n	%		
Obese	12	80.0	3	20.0	15	100.0	0.331	0.006
Overweight	11	84.6	2	15.4	13	100.0		
Normal	19	47.5	21	52.5	40	100.0		
Total	41	61.8	26	39.2	68	100.0		

n, number of respondents.

Table 3. Cross table of physical activity level on short-term memory ability

Physical Activity Level	Short Term Memory Ability						Correlation	P-value
	Low		Average		Total			
	f	%	f	%	f	%		
Low	33	84.6	6	15.4	39	100.0	0.555	0.000
Moderate	7	36.8	12	63.2	19	100.0		
High	2	20.0	8	80.0	10	100.0		
Total	42	61.8	26	38.2	68	100.0		

n, number of respondents.

DISCUSSION

From the inclusion and exclusion criteria selection, the number of research subjects obtained was 68. The results of this study found that subjects who had obese nutritional status 15 people (22.1%), overweight 13 people (19.1%), and 40 people (58.8%) had normal nutritional status. Several factors can cause differences in nutritional status in children. Some of them are the factors of food intake in children, parental income, education, parental characteristics, knowledge about nutritional status, and snacking habits.¹²

According to the PAQ-C questionnaire, 57.4% of children were low in physical activity; 27.9% were moderate, and 14.7% were high. The Digit Span Test was used to measure short-term memory. It was found that 61.8% had low short-term memory, and 38.2% had average short-term memory.

This study found a relationship between nutritional status and short-term memory abilities seen from the results of the Spearman rho analysis test, which showed a value of $p=0.006$. These results aligned with previous research by Lentoor (2022) and Yang et al. (2020).^{13,14} Research from Winarsih (2021) states a positive relationship between nutritional status and short-term memory abilities in children. Children who have normal nutritional status have better short-term memory abilities. Meanwhile, children with abnormal nutritional status, i.e., more or less, showed decreased short-term memory abilities.¹⁵

However, Saleh et al. (2020) obtained different results. In the study results, there was no difference between children with normal nutritional status and those who were deficient. Children with growth

problems can be due to problematic endocrine factors, not poor nutritional intake. Other factors affect the process of growth and development of children. One of the stimuli that can affect cognitive development is parental cognitive stimulation. Parental cognitive stimulation is how parents work to provide good teaching to improve children's cognitive and language development with activities that can enhance learning and facilitate an appropriate environment.¹⁶

The difference in these results could be due to the different number of subjects; in the study by Saleh et al., the research subjects were set at 165 people. In addition, in this study, the measurement tools to determine the nutritional status of children are also different from a study conducted by Saleh et al., determining the nutritional status of children with anthropometry using height or length according to age and focusing on children who are stunted. In this study, there were also different inclusion and exclusion criteria. In Saleh et al. study, the inclusion criteria were students aged³ 6 in grades 1-6. The inclusion criteria were cooperative children when collecting data, could not listen, had behavioural disorders such as attention deficit hyperactive disorder (ADHD) and Autism, had a history of epilepsy, meningitis, brain infection, cerebral palsy, and other diseases that interfere with cognitive function. As well as other factors that influence cognitive development, such as genetic factors, culture and cognitive stimulation, were not examined in this study.

Nutritional status influences brain performance. The main energy in the form of glucose, obtained from the food consumed, is needed to optimise the

brain. Foods that contain lots of glucose are obtained from consuming carbohydrates. If the brain lacks glucose, it will be difficult to concentrate. Children with obese nutritional status experience decreased short-term memory by 52.9%. Obesity causes an increase in blood cholesterol levels, inhibiting the process of delivering nutrients to the brain.¹⁷ Children with poor nutritional status (more or less) experience an imbalance of glucose. This affects the nervous system of the brain in the limbic system in the hippocampus; the hippocampus is thought to play an important role in determining the ability of the brain to receive and store memories which will affect the ability to remember in children to be high or good.¹⁸

A study conducted at the 5th Elementary School of Peguyangan showed that some children with good nutritional status had low short-term memory abilities. This condition can be caused by other factors that affect memory. Lestari (2013) stated that motivational factors and the surrounding environment affect short-term memory ability. Conducive environmental conditions will support children's concentration so they will more easily remember what they hear and see.¹⁹

The results obtained from this study are that there is a relationship between the level of physical activity and the ability to short-term memory. This can be seen from the Spearman rho analysis test results, which resulted in the value of $p = 0.000$. According to Andayani and Nugraha (2020), there is a significant positive relationship between the level of physical activity and the ability of short-term memory with a correlation coefficient of 0.375 and $p = 0.003$ ($p < 0.05$).²⁰ Piepmeier (2015) found similar results where there was a positive effect on cognitive performance on short and long-term memory abilities. This is because physical activity induces the release of serum brain-derived neurotrophic factor (BDNF).²¹

In previous studies, it was stated that someone diligent in doing physical activity with sufficient intensity would experience an increase in cerebral blood flow in the anterior cingulate cortex (ACC), as an increase in verbal memory is associated with an increase in cerebral blood flow in the hippocampus. The aerobic activity of brisk walking increases levels of insulin growth factor-1 (IGF-1), vascular endothelial growth factor (VEGF), and brain-derived neurotrophic factor (BDNF). This protein was carried through the Blood Brain Barrier (BBB) to the brain to regulate the process of neurogenesis in the hippocampus. IGF-1 is a protein that acts as an anti-apoptotic and stimulates cell proliferation in the brain, such as microglia, astrocytes, and oligodendrocytes in the white matter.²²

BDNF protein is one of the neurotrophins from growth factors and is a neuroprotective agent that prevents neurodegenerative processes. The BDNF protein not only influences degenerative processes but also induces neurogenesis and synapse plasticity and modulates the organisation of synaptic structures, thus playing an important role in learning processes, higher-order thinking, mood regulation, and affection.²³

Putra et al. (2021) found a significant relationship between physical activity levels and increased learning concentration in students. In the end, there will be harmony between physical fitness and physiological fitness, which will increase students' learning ability and achievement at school. Students can improve their learning concentration by increasing their physical exercise.²⁴

However, physical exercise can only affect cognitive skills at the age when they develop or decline. Immature neural circuits are more vulnerable to experience and may be more easily impacted by physical exercise than mature brain regions.²⁵ In a study at the 5th Elementary School of Peguyangan, several children had low physical activity levels but average short-term memory skills. Other factors can affect research, one of which is environmental conditions. Unfavourable environmental conditions can cause memory loss, such as heat, darkness, and noise.

The limitation of this research is that researchers do not control for other factors, namely external factors such as the place where research is carried out. The environment where research is done can affect the children's attention. Conditions that are not conducive will affect the child's concentration so that the child is less able to hear the numbers spoken by the researcher. However, researchers have tried to prepare conducive classrooms with a range of tests. Additionally, the nutritional status of subjects who participated in the study only consisted of good nutritional status, overnutrition, and obesity. There was no representation of subjects with undernutrition who participated in the study. This is due to the type of cross-sectional research method and the need for longitudinal studies such as cohort or case control.

CONCLUSION

Based on this research, it can be concluded that there was a relationship between nutritional status and short-term memory ability in children aged 9-11 years at the 5th Elementary School of Peguyangan. Moreover, there was a relationship between physical activity and short-term memory ability in children aged 9-11 years at the 5th Elementary School of Peguyangan.

ETHICAL CLEARANCE

The Research Ethics Commission, Faculty of Medicine, Universitas Udayana, stated that this research is ethically feasible with number 1799/UN14.2.2.VII.14/LT/2022.

CONFLICT OF INTEREST

This study has no conflict of interest.

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AUTHOR CONTRIBUTIONS

PBP is preparing study designs, collecting data, processing data and writing manuscripts. MHSN, NPGKS, and IPYP are directing data collection and revising the manuscript.

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