Epidemiology

Learning outcomes vis-à-vis nutritional status, physical activity, and cognitive function: a cross-sectional study

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Abstract - Aim: In this regard, this cross-sectional study aims to determine the relationship of nutritional status, physical activity, and cognitive function to the learning outcomes of junior high school students in the country. **Methods:** This study employed a correlational approach in order to determine the relationship among the variables. A total of 98, 289 students from the junior high schools served as the study's sample population. Due to time constraints, data from 1870 students were used to draw conclusions using Simple Random sampling technique. The Physical Activity Questionnaire for Older Children (PAQ-C) was utilized in the study. Additionally, concerning food intake, is determined by Body Mass Index (BMI). Moreover, the academic performance was measured by depending on the grades or numerical representations, using the Concentration Grid Test to measure cognitive function (CGT). The F-test, coupled with correlation and multiple regression analysis, was used to analyze the data in this study. Furthermore, this present study has performed the required tests, namely test of normality and linearity test, before testing the hypothesis. **Results:** It was observed that there is a positive and significant relationship between nutritional status (X1) [$r(1868) = 0.870$, $p = 0.001$], physical activity (X2) [$r(1868) = 0.748$, $p = 0.013$], and cognitive function (X3) [$r(1868) = 0.895$, $p < 0.05$] (X3) with learning outcomes. Furthermore, a significant relationship was also observed between nutritional status (X1) and physical activity (X2) [$r(1868) = 0.742$, $p = 0.014$], and nutritional status (X1) and cognitive function (X3) [$r(1868) = 0.857$, $p = 0.002$]. Based on the multiple regression results, dietary intake (X1), physical activity (X2), cognitive function (X3), and learning outcomes (Y) have a 0.725 association. Nutritional status (X1), physical activity (X2), and cognitive function (X3) account for 52.5% of learning outcomes (Y), whereas other variables account for 47.5%. Sig. F change 0.006 ($p < 0.05$) shows a simultaneous and substantial association between nutritional status (X1), physical activity (X2), and cognitive performance (X3) among junior high school students. **Conclusion:** Nutritional status, physical activity, cognitive function, and learning outcomes are strongly linked. Future studies should compare rural and urban students' dietary status, physical activity, cognitive performance, and educational outcomes.

Keywords: cognitive function, learning outcomes, nutritional status, physical activity.

Introduction

Human capital can be developed further through the use of physical education in schools[1,2]. Improving effective learning outcomes in schools requires providing children with adequate dietary conditions or a good nutritional status that will inspire them to desire to learn[3,4,5], in addition to using the facilities and infrastructure that are already in place and having teachers available. Excellent physical health is required for the study of physical education at school, and this can only be achieved through a balanced diet in which the amount of energy and nutrients taken is equal to the amount required by the body and the amount exhaled by the body[6,7,8]. Furthermore, children who par-

take in physical education activities at school should fuel themselves on healthy, calorie-dense foods like carbs, lipids, and proteins before arriving at class[9,10]. When the ratios between these nutrients are awry, it can lead to malnutrition[11,12,13], therefore it's important to keep an eye on them. Consumption of food and the state of one's nutrition are both essential for proper body functioning[14]. Nutrition requires a state of energetic equilibrium between food consumption and energy expenditure[15,16]. Nutritional status is a quantifiable indicator of health and nutrient utilization[17].

Nutritional status can be affected by many different variables, such as diet and lifestyle choices[18,19], mental health[20,21], level of education[22], maternal employment[23], and disposable income[24]. Furthermore, it was known that students' cognitive abilities and their ability to learn might be affected by their diet[25,26]. Students in good nutritional health are more likely to succeed academically and have a positive impact on their campus community than their undernourished or over nourished counterparts[27]. Awareness of health concerns is an important life skill for everyone, but it is especially important for kids in middle school. One of the decisive factors is the nutritional quality of the food that children consume on a daily basis. Proper nutrition is the bedrock of a child's development and health. Kids need to eat to keep their bodies running smoothly, and if they don't receive enough, they may develop health problems later in life[28]. For optimal development and learning in children, it is crucial to have a firm grasp on the different types of nutrients and their food sources. Children's nutritional status is also an indicator of the success of multi-sectoral development initiatives, such as those focused on education. On the other hand, exercise and mental acuity can have an effect on classroom PE lessons as well. A person's health and wellbeing may be predicted by their school age[29,30,31]. The surprising truth is that even a small amount of exercise may do wonders for the mental health, from warding off sadness to easing loneliness and stress to improving the quality of sleep. However, it has been suggested that engaging in excessive exercise can impair cognitive performance, rendering the benefits of learning physical education at school inconsequential[32,33]. Although research on the link between exercise and cognitive function in physical education learning outcomes has been conducted at a high level in recent years, it has gotten far less attention among school-aged children. In spite of the fact that everyone is in agreement that starting school is the best moment to begin forming healthy living habits, on the other hand, in order to maintain preparedness for the future, academics feel the need to attempt to explain why this occurrence occurs at such a young age. Research has been conducted on diet, physical activity, and academic performance; however, there have been no studies conducted on the cognitive function of students, particularly in the setting of the Indonesia, and Philippines and particularly since the emergence of the new normal. Thus, study aims to determine the relationship of nutritional status, physical activity, and cognitive function to the learning outcomes of junior high school students in the country.

Methods

Study design

This study employs a correlational statistical strategy to probe the connection between the variables. This study used a technique known as cross-sectional research, which involves collecting data through multiple, consecutive measurements or observations.

Participants

This analysis uses data from February 2023 to May 2023. This study was conducted in Indonesia (n = 6.446), and the Philippines (n = 20.000). The sample population for this analysis consisted of 26.446 students (male) from junior high schools located in one area of both countries. Because of the limited amount of time available, a total of 1870 students were used to make up the sample (Indonesia: n = 870, Philippines: n = 1000). In order to come up with the total sample, the study have utilized Simple Random sampling. This study has been approved by the local ethics committee of junior high schools under the auspices of Surabaya State University, Indonesia (registration number: B/40962/UN38.6/LT.02.02/2024), and junior high schools in the Philippines (registration number: Privacy Act of 2012-RA-10173). In addition, all activities in this study followed the Declaration of Helsinki.

Measures

This research largely relied on the use of online questionnaires. The Physical Activity Questionnaire for Older Children (PAQ-C) was utilized in the study. Additionally, concerning food intake, is determined by Body Mass Index (BMI). Moreover, the academic performance was measured by depending on the grades or numerical representations, using the Concentration Grid Test to measure cognitive function (CGT).

Statistical analysis

The F-test, coupled with correlation and multiple regression analysis, was used to analyze the data in this study. Furthermore, this present study has performed the required tests, namely test of normality and linearity test, before testing the hypothesis. The investigation examined the relationships between four factors: nutritional status, physical activity, cognitive function, and the effects of physical education on student learning. The analysis of data was processed via IBM SPSS 27.

Ethical considerations

All participants were briefed on the experiment's goals, as well as any instruments or tests that would be used to evaluate their progress and output. The positive effects that this investigation will have on educational institutions and the scientific community as a whole have also been outlined.

Result

First, learning outcomes have a p-value of 0.080 ($p > 0.05$) on the Shapiro-Wilk test, while nutritional status = 0.977, physical activity = 0.258, and cognitive function = 0.05, indicating that the data is normally distributed. Results are illustrated in Table 1.

According to Table 2, the tolerance value for the nutritional status variable is 0.218, the tolerance value for the physical activity variable is 0.443, and the tolerance value for the cognitive function variable is 0.262; all of these values are greater than 0.10. The VIF values for variables nutritional status, physical activity, and cognitive function are 4.581 10.00, 2.258 10.00, and 3.812 10.00. According to the logic underpinning the multicollinearity test's conclusion, the regression model does not show any evidence of multicollinearity.

Table 3 illustrates the correlational analysis performed among the variables being studied. It was observed that there is a positive and significant relationship between nutritional status [$r(1868) = 0.870$, $p = 0.001$], physical activity [$r(1868) = 0.748$, $p = 0.013$], and cognitive function [$r(1868) = 0.895$, $p < 0.05$] with learning outcomes. Furthermore, a significant relationship was also observed between nutritional status and physical activity [$r(1868) = 0.742$, $p = 0.014$], and nutritional status and cognitive function [$r(1868) = 0.857$, $p = 0.002$].

Table 1 - Normality test.

Variables	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Learning outcomes	0.305	1870	0.0900	0.781	1870	0.080
Nutritional status	0.099	1870	0.200*	0.983	1870	0.978
Physical activity	0.222	1870	0.178	0.906	1870	0.258
Cognitive function	0.272	1870	0.053	0.802	1870	0.051

It can be seen from Table 4 (summary model) that there is a highly significant relationship between dietary intake, physical activity, and cognitive ability and academic performance, with a calculated correlation coefficient of 0.725. Nutritional status factors, physical activity, and cognitive function jointly account for 52.5% of the variance in learning outcomes, whereas other variables account for the remaining 47.5%. Junior high school pupils, have a simultaneous and significant relationship with nutritional status, physical activity, and cognitive performance, as indicated by the value of sig. F change 0.006 ($p < 0.05$).

Discussion

Our current research aims to determine the relationship between nutritional status, physical activity, and cognitive function on learning outcomes of junior high school students in the country.

Our main findings show that there is a significant correlation among the variables studied. It was observed that there is a positive and significant relationship between nutritional status, physical activity and cognitive function with learning outcomes. The data proves that there is a large relationship in each variable. The results showed that despite the fact that frequent exercise helps to maintain healthy blood flow and transport nutrients to the brain, almost all respondents engaged in less physical activity, such as daily morning walks. The results of the study on cognitive function showed that nearly half of the respondents (or 77.81%) had cognitive function below 1455, and that as many as 415 respondents (19.68%) had moderate cognitive function. According to the results, almost all of the junior high school pupils reported experiencing a loss in mental capacity. Many survey participants reported declining mental capacity as a result of insufficient exercise, consistent with other research linking inactivity to cognitive decline. Meanwhile, since rxy > r table at the 0.05 level of significance, this present investigation infers that nutritional status also significantly affects learning results. On the other hand, good ratings of cognitive function are associated with high levels of routine and physical activity. Moreover, kids whose physical activity levels are only moderate to high had worse cognitive outcomes. Pre-

Table 2 - Coefficients.

Model	Unstandardized coefficients		Standardized coefficients	*t*	Sig.	Collinearity statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	0.528	1.544		0.342	0.744		
Nutritional status	0.127	0.150	0.281	0.844	0.431	0.218	4.581
Physical activity	0.146	0.192	0.178	0.760	0.476	0.443	2.258
Cognitive function	0.552	0.315	0.533	1.755	0.130	0.262	3.812

Note. Dependent variable: learning outcomes.

Table 3 - Correlational analysis results.

Variables		Nutritional status	Physical activity	Cognitive function	Learning outcomes
Nutritional status	Pearson Correlation	1	0.742*	0.857**	0.870**
	Sig. (2-tailed)		0.014	0.002	0.001
	N	1870	1870	1870	1870
Physical activity	Pearson Correlation	0.742*	1	0.678*	0.748*
	Sig. (2-tailed)	0.014		0.031	0.013
	N	1870	1870	1870	1870
Cognitive function	Pearson Correlation	0.857**	0.678*	1	0.895**
	Sig. (2-tailed)	0.002	0.031		0.000
	N	1870	1870	1870	1870
Learning outcomes	Pearson Correlation	0.870**	0.748*	0.895**	1
	Sig. (2-tailed)	0.001	0.013	0.000	
	N	1870	1870	1870	1870

*Correlation is significant at the 0.05 level (2-tailed).

Table 4 - Model summary.

Model	R	R square	Adjusted R square	Std. error of the estimate	Change statistics				
					R square change	*F* change	df1	df2	Sig. *F* change
1	0.725a	0.525	0.782	0.32642	0.855	11.765	561	1122	0.006

vious research has shown that regular physical activity has a positive effect on a person's executive function, attention, cognitive speed, working memory, and both long- and short-term memory[35,36,37,38]. Additionally, the frequency and intensity of one's exercise habits can reduce the risk of cognitive decline[39,40]. Strong cognitive function, and cognitive decline are linked to sustained and robust levels of physical activity, as reported by[41]. Physical activity has been shown to be helpful when a person's outward appearance is three years younger than their true age, and even 20% less physical activity can reduce the chance of cognitive deterioration[42]. Generally, aging is associated with a decline in cognitive ability. Risk factors for cognitive decline include, but are not limited to, a personal or family history of Parkinson's disease, heart disease, stroke, diabetes, or any of a number of other neurological or metabolic disorders; one's level of education; exposure to environmental contaminants; inactivity; and the like[43,44]. Findings suggest that children who engage in regular physical activity and fitness have improved academic performance, learning, and cognitive function[45,46,47]. This has sparked a renewed interest among researchers and policymakers in the link between physical activity and academic success.

This present investigation conducted a three-part search for studies that employed fitness and exercise metrics to evaluate the strength of an association or effect on (a) academic performance and (b) mental acuity. The data extraction technique used 18 papers: 11 correlational studies, 6 quasi-experimental studies, and 1 randomized control trial. The criteria for assessing the correlation between exercise and mental acuity were not met by any of the available studies. The beneficial associations between exercise, healthiness, academic achievement, and brain function were not supported by the interventions. According to another definition, nutrition is the intake of nutrients necessary for growth and health maintenance. Since nutrition provides fuel, aids in cellular growth and tissue maintenance, and regulates metabolic processes, it is often used interchangeably with “health”. A person's nutritional status may be defined as the presence or absence of key nutrient-containing compounds in the body. Mbhatsani et al.[48] define nutrition as the metabolic process of food and the elimination of substances that are not required for maintaining life, growing, maintaining appropriate organ function, and producing energy. Daily life requires a steady supply of energy, which comes from the food people consume. According to Murphy and Murtagh[49], basal metabolic activities, which the body uses to keep itself running, need 60-70% of the body's total energy needs. This suggests that the body has a low energy requirement during total rest but not during sleep. However, more energy is required for other tasks, such as walking, working, eating, and researching. The results of the study are comparable to the effects of underweight and overweight nutritional status on students’ ability to learn, with the latter having a more significant impact. However, it cannot be denied that eating too much can have negative

effects on one's weight and health. As a result, overeating might make it difficult to concentrate on schoolwork and lead to exhaustion. Two internal and external components, in addition to the external dietary elements, affect learning success and achievement. The support of one's family and community, as well as one's physical and mental health, are all examples of internal influences. On the one side, external factors include things like one's family, surroundings, teachers, community, schools, and other educational facilities. It is clear from these that many factors, including parental engagement, educational resources, study time, motivation, IQ, interest, teacher teaching talents, and such, affect academic success. Such features allow one to argue that people with underweight nutritional status can attain good results and poor ratings, as well as normal and overweight nutritional status. Consuming the nutrients, the body demands is one strategy to improve academic performance, and so a balanced diet will have an effect on students' grades. Meanwhile, a person's intelligence, drive, and the quality of their home, community, and educational institution all play a role in how well they learn and perform[50,51]. Cognitive ability improves in tandem with increased physical activity. Students' mental health is linked to their level of physical activity. As one's level of physical activity rises, so does one's cognitive function score. However, we observed that there are still some limitations in this study, for example, the students who participated came from only one region in Indonesia and the Philippines, so that the results have not been generalized as a whole. In addition, another limitation is that the participants involved were only male. Future research that takes consideration of gender, socioeconomic status, and familial factors in relation to cognitive performance and physical activity is expected to take into account the results of this study.

Conclusions

It is possible to make the assertion that there is a substantial association between junior high school pupils' nutritional status, physical activity, cognitive performance, and the learning outcomes. This research can be important information for teachers, and students regarding the importance of the role of nutritional status, physical activity, cognitive performance aspects for the development of students' learning outcomes in physical education classes. Thus, several aspects must continue to be evaluated and developed optimally in order to produce better learning outcomes than before.

Conflict of interest statement

No conflict of interest involved in the completion of this study among the authors.

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