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Associations between physical activity, nutritional status, and gross motor competence among elementary school children in lembah melintang district

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Abstract: The background of this research is that there are still elementary school children in Lembah Melintang District with low levels of physical activity and nutritional status that is not yet normal, which has the potential to affect the development of gross motor skills. Variations in physical activity, nutritional status, and lack of involvement in structured physical activities and active games, coupled with differences in parenting patterns and parental attention, are thought to be related to differences in gross motor skills in children. This study aims to determine the relationship between physical activity and gross motor skills of elementary school children in Lembah Melintang District, to determine the relationship between nutritional status and gross motor skills of elementary school children in Lembah Melintang District, and to determine the relationship between physical activity and nutritional status and gross motor skills of elementary school children in Lembah Melintang District. This study uses a quantitative approach with an associative research type. With a population and sample of 45 students using a total sampling technique. The research variables consist of physical activity, nutritional status, and gross motor skills which are measured using the PAQ-C instrument, anthropometric measurements, and gross motor tests in the form of running and jumping. Data analysis techniques include descriptive analysis, prerequisite tests, and inferential analysis. The results of the study showed that there was a relationship between physical activity and gross motor skills (R 0.404) with a contribution of 16.3%, and nutritional status had a relationship with gross motor skills (R 0.334) with a contribution of 11.2%. There was also a relationship between physical activity and nutritional status with gross motor skills (R 0.519) with a contribution of 26.9%, so it was proven that they complement each other in supporting the gross motor development of elementary school children.

Keywords: Physical activity, Nutritional status, Children's gross motor ability

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INTRODUCTION

Basic education is an important foundation for children's overall development, encompassing cognitive, affective, and psychomotor domains. Gross motor competence represents one of the fundamental determinants of children's readiness to learn and participate successfully in school activities (Jones et al., 2021; Barnett et al., 2022; Iivonen et al 2014). Gross motor skills involve coordinated movements of large muscle groups, including running, jumping, throwing, catching, balancing, and body coordination (Robinson et al., 2015; Bernett et al., 2016; Biino et al., 2023).These skills provide the foundation for lifelong participation in physical activity, organized sports, and social interaction while enhancing children's self-confidence, physical competence, and school engagement (Lubans et al., 2016; WHO, 2020). Gross motor development is influenced by numerous biological and environmental factors, particularly habitual physical activity and nutritional status, both of which contribute substantially to muscular strength, balance, coordination, agility, and cardiorespiratory fitness during elementary school years (Bull et al., 2020; Poitras et al., 2016).

According to contemporary motor development theory, gross motor competence develops through repeated, meaningful, and developmentally appropriate movement experiences (Robinson et al., 2015; Wang, 2004). Frequent participation in physical activity enhances neuromuscular adaptation, motor coordination, and movement efficiency. Consequently, physical activity demonstrates a direct functional relationship with gross motor competence because activities such as active play, sports participation, and physical education strengthen large muscle groups, improve movement coordination, and accelerate motor responses (Kohl III et al., 2013). Moreover, regular movement stimulates central nervous system maturation and motor control, whereas physically inactive children are more likely to demonstrate delayed motor competence and poorer movement proficiency (WHO, 2020; Lubans et al., 2016).

Nutritional status is another essential determinant of children's gross motor competence because it reflects the balance between nutrient intake and physiological requirements necessary for growth, development, and physical activity (Black et al., 2013; Victora et al., 2021). Children with adequate nutritional status generally possess greater muscle mass, sufficient energy reserves, and optimal physiological functioning, whereas undernutrition and overnutrition may impair muscle performance, increase fatigue, and reduce movement efficiency (Karava et al., 2023; Black et al., 2013). Adequate intake of macronutrients and micronutrients contributes significantly to skeletal growth, muscle development, bone mineralization, and neuromuscular coordination, resulting in superior gross motor performance among children with normal nutritional status (Victora et al., 2021).

Environmental characteristics also contribute significantly to children's motor development. Previous international studies have demonstrated that access to safe play environments, recreational facilities, and supportive neighborhood characteristics significantly influence children's physical activity participation and motor competence (Barnett et al., 2022; Reimers et al., 2018). Children living in different geographical settings often display distinct motor competence profiles because environmental opportunities determine the frequency and quality of movement experiences available during childhood (Barnett et al., 2022).

METHOD

This study employed a quantitative approach with an associative correlational design to examine the relationships between physical activity, nutritional status, and gross motor ability among elementary school children in Lembah Melintang District, West Pasaman Regency, Indonesia. A correlational design was considered appropriate because the study sought to determine the magnitude and direction of the relationships among naturally occurring variables without manipulating the research conditions (Creswell & Creswell, 2023). Correlational research is widely recommended for investigating associations among health- and education-related variables in school-aged populations while preserving ecological validity (Fraenkel et al., 2023).

The study was conducted from January 12 to 15, 2026, at SD Muhammadiyah 01 Lembah Melintang and SD Negeri 25 Lembah Melintang. These schools were purposively selected because they represent public and private elementary schools in the district, implement comparable physical education curricula, and granted permission for anthropometric measurements and motor testing. The target population consisted of all fifth-grade students enrolled in the two schools ($N = 45$). Since the accessible population was relatively small, a total sampling technique was adopted, whereby every eligible student participated in the study. To evaluate whether this sample size was adequate for multiple correlation analysis, an a priori power analysis was conducted using G*Power 3.1 for multiple linear regression with two predictors, assuming a medium effect size ($f^2 = 0.15$), $\alpha = .05$, and statistical power ($1 - \beta$) = .80. The analysis indicated a minimum sample of approximately 43 participants; therefore, the inclusion of all 45 students satisfied the minimum sample size requirement for detecting medium-sized effects (Giner-Sorolla et al., 2024; Dattalo, 2008). Conducting an a priori power analysis is recommended to minimize the risk of Type II error and improve statistical validity in behavioral research (Aberson, 2019; Uttley, 2019).

The study included two independent variables—physical activity (X_1) and nutritional status (X_2)—and one dependent variable, gross motor ability (Y). Physical activity was assessed using the Physical Activity Questionnaire for Older Children (PAQ-C), a validated self-administered instrument consisting of nine scored items that evaluate moderate-to-vigorous physical activity performed during the previous seven days (Kowalski et al., 2004). The PAQ-C has demonstrated satisfactory construct validity and internal consistency in children across different populations, with Cronbach's alpha generally ranging from 0.72 to 0.89 (Thomas & Upton, 2014). Recent systematic reviews have further confirmed the PAQ-C as one of the most reliable self-report instruments for assessing habitual physical activity among school-aged children (Voss et al., 2013). In the present study, the questionnaire demonstrated good internal consistency, with a Cronbach's alpha coefficient of 0.81, indicating acceptable reliability according to established psychometric criteria (Taber, 2018).

Nutritional status was determined through anthropometric assessment following the World Health Organization (WHO) standardized procedures. Body weight was measured to the nearest 0.1 kg using a calibrated digital scale, while standing height was measured to the nearest 0.1 cm using a portable stadiometer. Body Mass Index (BMI) was subsequently calculated as weight (kg)/height^2 (m^2), and nutritional status was classified according to the WHO BMI-for-age reference standards for children aged 5–19 years (WHO, 2007). BMI-for-age is internationally recognized as an appropriate indicator for monitoring nutritional status among school-aged children because it reflects both undernutrition and overweight status associated with growth and health outcomes (de Onis et al., 2007; World Health Organization, 2022).

Gross motor ability was evaluated using the Test of Gross Motor Development–Third Edition (TGMD-3) (Ulrich, 2019), a standardized assessment widely used to measure fundamental movement skills in children. The assessment included selected locomotor skills, particularly running and horizontal jumping, which represent speed, lower-body power, balance, and movement coordination. Each skill consisted of clearly defined performance criteria scored dichotomously (1 = criterion achieved; 0 = criterion not achieved) across two test trials following standardized administration procedures. The TGMD-3 has demonstrated excellent construct validity and reliability across diverse cultural contexts and has become one of the most frequently used instruments for evaluating children's motor competence (Webster et al., 2017; Barnett et al., 2022). All assessments were conducted by two trained physical education evaluators. Prior to data collection, the evaluators completed calibration sessions using the TGMD-3 administration manual. Inter-rater reliability was assessed using the Intraclass Correlation Coefficient (ICC), yielding an ICC value of 0.92, which indicates excellent agreement between raters (Ohata et al, 2026).

Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize participant characteristics and study variables. Prior to inferential analysis, assumptions of normality and linearity were examined using the Shapiro–Wilk test and linearity analysis, respectively. The Shapiro–Wilk test is recommended for studies involving relatively small samples because of its superior statistical power compared with alternative normality tests (Razali & Wah, 2011). Pearson product–moment correlation analysis was employed to examine the bivariate relationships between variables, while multiple correlation analysis was conducted to determine the combined contribution of physical activity and nutritional status to gross motor ability. Effect sizes were interpreted following Cohen's (1988) recommendations to facilitate practical interpretation of the findings. Statistical significance was established at $p < .05$, and all analyses were performed using IBM SPSS Statistics version 27.

RESULTS AND DISCUSSION

Data Description

Table 1. Respondent Description Data by Gender

Yes	Gender	Frequency	Percentage (%)
1	Male	26	58
2	Women	19	42

From the table, it is known that out of 45 respondents, as many as 26 respondents (58%) are male and 19 respondents (42%) are female, so the majority of respondents are male. This description can be visualized in the form of a bar chart in the image below.

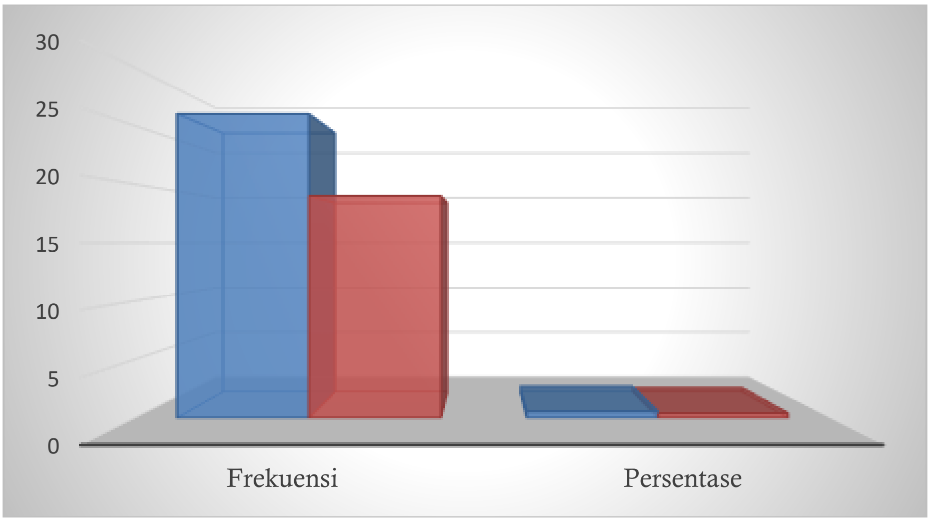

Figure 1. Respondent Description by Gender

Table 2. Respondent Description Data by School of Origin

Yes	School Name	Frequency	Percentage (%)
1	SD 01 Muhammadiyah Lembah Melintang	12	27
2	SD Negeri 25 Lembah Melintang	33	73

From the table, it is known that out of 45 respondents, as many as 33 respondents (73%) came from SD Negeri 25 Lembah Melintang and 12 respondents (27%) from SD 01 Muhammadiyah Lembah Melintang, so that the majority of respondents came from SD Negeri 25 Lembah Melintang. This description can be visualized in the form of a bar chart in Figure 2.

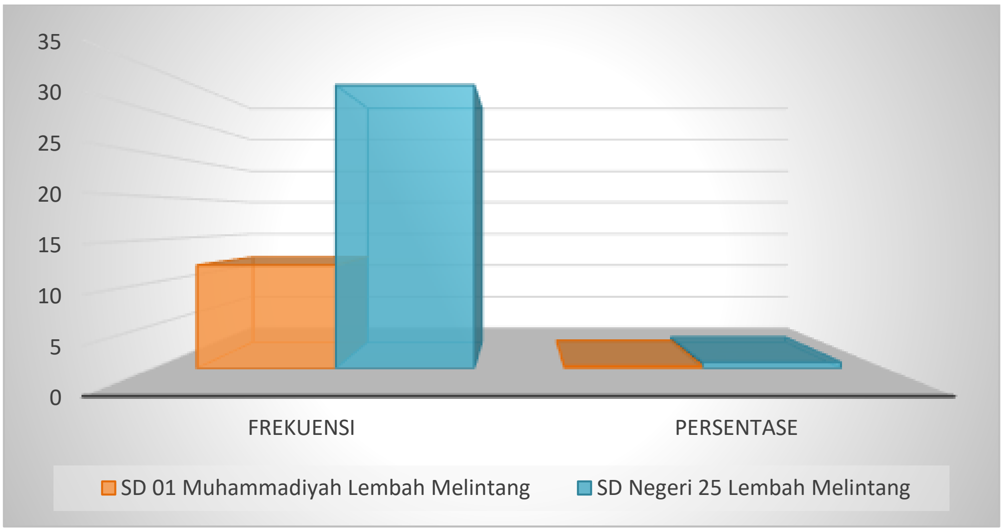

Figure 2 Respondent Description by School Origin

Table 3. Respondent Description Data by Nutritional Status

Category: Status Secret	Frequency	Percentage (%)
Malnutrition	3	7
Normal nutrition	37	82
More nutrition	5	11

From the table, it is known that out of 45 respondents, as many as 37 respondents (82%) have normal nutrition, 5 respondents (11%) are overnutritional, and 3 respondents (7%) are undernourished, so that the majority of respondents have normal nutritional status. This description can be visualized in the form of a bar chart in the image below:

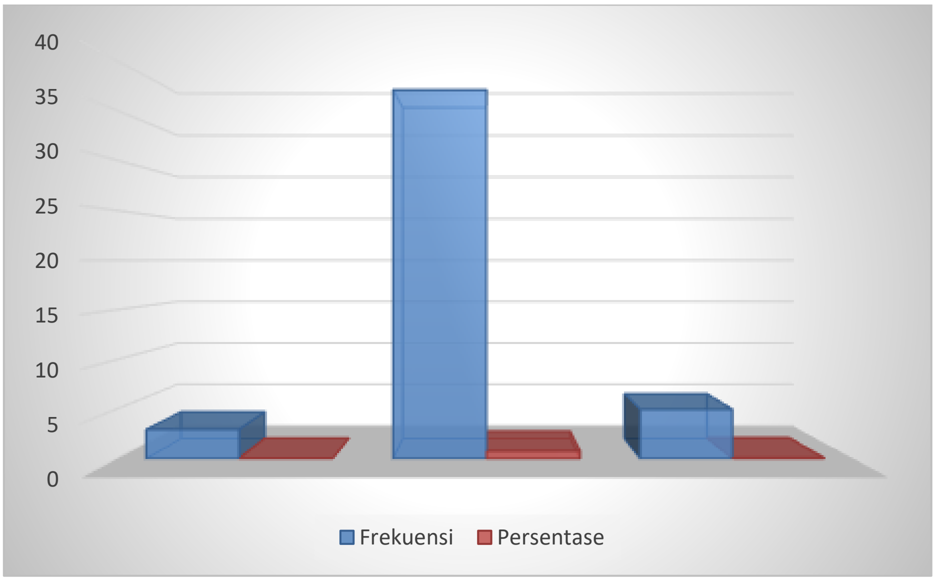

Figure 3. Respondent Description by Nutritional Status Category

Data Analysis

Analysis Prerequisites Test

Normality Test

Based on the table 4, it is known that the significance value of Kolmogorov-Smirnov is 0.200 > 0.05, so that the regression model in this study is normally distributed, which is also supported by the results of the analysis of the Normal Probability Plot graph in figure 4.

Table 4. Kolmogorov-Smirnov Test

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residual
N		45
Normal Parametersa,b	Mean	0.0000000
	Std. Deviation	6.39250486
Most Extreme Differences	Absolute	0.069
	Positive	0.069
	Negative	-0.049
Test Statistic		0.069
Asymp. Sig. (2-tailed)		.200c,d

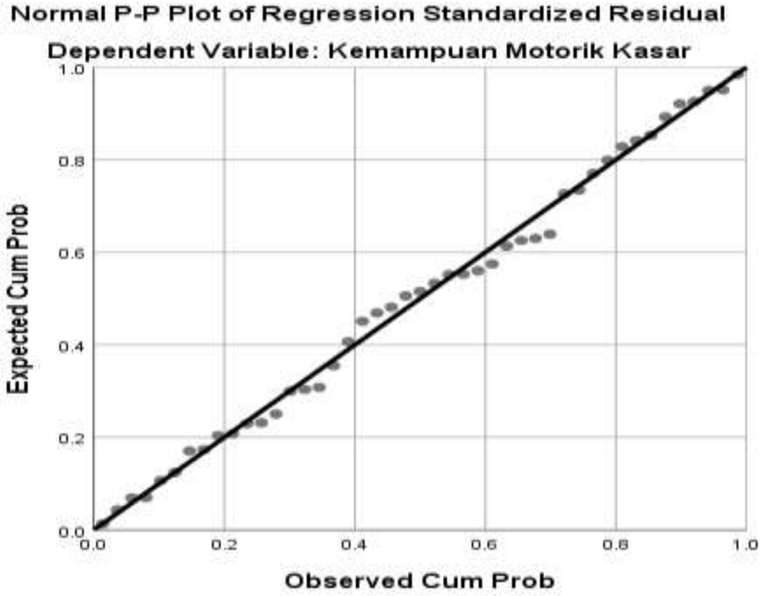

Figure 4. P-Plot Fork

Linearity Test

Table 5. Physical Activity on Gross Motor Ability of Elementary School Children in Lembah Melintang District

ANOVA Table							
			Sum of Squares	**df**	**Mean Square**	**F**	**Say.**
Gross Motor Ability * Physical Activity	Between Groups	(Combined)	1451.944	21	69.140	1.576	0.145
		Linearity	401.940	1	401.940	9.162	0.006
		Deviation from Linearity	1050.004	20	52.500	1.197	0.337
	Within Groups		1009.033	23	43.871		
	Total		2460.978	44			

Based on the table, it is known that the value of Sig. dev. from linearity > α (0.337 > 0.05), so it can be concluded that the relationship between physical activity and gross motor skills of elementary school children in Lembah Melintang District is linear.

Based on the table 6, it can be seen that the value of Sig. dev.from linearity > α (0.065>0.05). Therefore, it can be concluded that the relationship between nutritional status and gross motor skills of elementary school children in Lembah Melintang sub-district is linear.

Table 6. Nutritional Status on Gross Motor Ability of Elementary School Children in Lembah Melintang District

ANOVA Table							
			Sum of Squares	**df**	**Mean Square**	**F**	**Say.**
Gross Motor Ability * Nutritional Status	Between Groups	(Combined)	2054.311	30	68.477	2.357	0.046
		Linearity	231.266	1	231.266	7.962	0.014
		Deviation from Linearity	1823.045	29	62.864	2.164	0.065
	Within Groups		406.667	14	29.048		
	Total		2460.978	44			

Correlation Coefficient and Determination Coefficient Test

Table 7. Correlation Coefficients and Coefficients of Physical Activity on Gross Motor Ability of Elementary School Children in Lembah Melintang District

Model Summaryb				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.404a	0.163	0.144	6.920

a. Predictors: (Constant), Physical Activity
b. Dependent Variable: Gross Motor Ability

Based on the table, an R value of 0.404 was obtained which was in the interval of 0.40–0.599, so it can be concluded that there is a relationship with a moderate or sufficient correlation level, with a contribution of 16.3% and the remaining 83.7% from other variables not included in this study.

Table 8. Correlation Coefficients and Nutritional Coefficients on Gross Motor Ability of Elementary School Children in Lembah Melintang District

Model Summaryb				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.334a	0.112	0.099	4.576

a. Predictors: (Constant), Status Gizi
b. Dependent Variable: Gross Motor Ability

Based on the table 8, an R value of 0.334 was obtained which was in the interval of 0.20–0.399, so it can be concluded that there is a relationship with a weak correlation level, with a contribution of 11.2% and the remaining 88.8% coming from other variables that are not included in this study.

Table 9. Correlation Coefficients and Coefficients of Physical Activity and Nutritional Status on Gross Motor Ability of Elementary School Children in Lembah Melintang District

Model Summaryb				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.519a	0.269	0.235	6.543

a. Predictors: (Constant), Nutritional Status, Physical Activity
b. Dependent Variable: Gross Motor Ability

Based on the table 9, an R value of 0.519 was obtained which was in the interval of 0.40–0.599, so it can be concluded that there is a relationship with a moderate or sufficient correlation level, with a contribution of 26.9% and the remaining 73.1% coming from other variables that are not included in this study.

Partial Test (t-test)

Table 10. Partial Test Table (t-Test) of the First Hypothesis

Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Say.**
		B	**Std. Error**	**Beta**		
1	(Constant)	48.741	18.557		2.627	0.002
	Physical Activity	0.408	0.141	0.404	2.897	0.006
a. Dependent Variable: Gross Motor Ability						

Based on the summary, a p-value of 0.002 < α (0.05) was obtained, so that the alternative hypothesis (H1) was accepted and the null hypothesis (H0) was rejected, which means that there is a significant relationship between physical activity and gross motor skills of elementary school children in Lembah Melintang District.

Table 11. Partial Test Table (t-Test) of the Second Hypothesis

Coefficients[a]						
		Unstandardized Coefficients		**Standardized Coefficients**		
Model		**B**	**Std. Error**	**Beta**	**t**	**Say.**
1	(Constant)	74.208	13.403		5.537	0.000
	Nutritional Status	0.161	0.076	0.307	2.112	0.004

a. Dependent Variable: Gross Motor Ability

Based on the summary, a p-value of 0.004 < α (0.05) was obtained, so that the alternative hypothesis (H1) was accepted and the null hypothesis (H0) was rejected, which means that there is a significant relationship between nutritional status and gross motor ability of elementary school children in Lembah Melintang District.

Simultaneous Test (Test f)

Table 12. Simultaneous Test Table (Test f)

ANOVA						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Say.**
1	Regression	662.957	2	331.478	7.743	.001b
	Residual	1798.021	42	42.810		
	Total	2460.978	44			

Based on the table, a p-value of 0.001 < α (0.05) was obtained, so that H0 was rejected and H1 was accepted, which means that there is a significant relationship between physical activity and nutritional status on the gross motor ability of elementary school children in Lembah Melintang District.

Relationship between Physical Activity and Gross Motor Ability

The results of this study indicate a significant positive relationship between physical activity and the gross motor ability of elementary school children in Lembah Melintang District (R = 0.404), representing a moderate correlation according to Cohen's (1988) criteria. Physical activity explained 16.3% of the variance in gross motor ability, whereas the remaining 83.7% may be attributed to other biological, environmental, and psychosocial factors. These findings are consistent with previous evidence demonstrating that physically active children generally exhibit higher levels of motor competence than their less active peers (Barnett et al., 2022;; Robinson et al., 2015).

The reciprocal relationship between physical activity and motor competence has been widely documented. The conceptual model proposed by Stodden et al. (2008) suggests that regular participation in physical activity enhances motor competence through repeated movement experiences, while improved motor competence subsequently encourages greater engagement in physical activity. This reciprocal pathway has been supported by recent longitudinal evidence demonstrating that children with higher motor competence are more likely to maintain active lifestyles throughout childhood and adolescence (Barnett et al., 2022).

Furthermore, systematic reviews have shown that structured physical activity programs significantly improve locomotor skills, object-control skills, balance, coordination, and muscular fitness among school-aged children (2018; Hassan et al., 2022; Robinson et al., 2015). Similar conclusions were reported by Graham et al (2022), who found that school-based physical activity interventions consistently produce moderate improvements in children's fundamental movement skills. Likewise, Fang Ren et al. (2026) reported that regular moderate-to-vigorous physical activity positively influences neuromuscular adaptation, movement efficiency, and motor coordination.

Although the present study identified a statistically significant relationship, physical activity accounted for only a modest proportion of the variance in gross motor ability. This finding suggests that motor development is multifactorial and influenced by additional determinants, including nutritional status, biological maturation, socioeconomic conditions, school environment, opportunities for active play, and parental support (Barnett et al., 2022; World Health Organization, 2020).

Relationship between Nutritional Status and Gross Motor Ability

The present study found a significant positive relationship between nutritional status and gross motor ability (R = 0.334), indicating a weak but meaningful association. Nutritional status explained 11.2% of the variation in children's motor competence, whereas the remaining variation may be explained by other developmental and environmental factors.

These findings are supported by international evidence demonstrating that adequate nutritional status is fundamental for children's musculoskeletal growth, neuromuscular development, and movement efficiency (Victora et al., 2021; Black et al., 2013). Proper nutrition provides sufficient energy, protein, essential fatty acids, vitamins, and minerals required for muscle development, bone mineralization, and neural maturation, all of which contribute to successful motor performance.

Prado and Dewey (2014) emphasized that adequate nutrition during childhood supports brain development and neuromotor function, thereby facilitating the acquisition of motor skills. More recent reviews have confirmed that chronic undernutrition, micronutrient deficiencies, and overweight or obesity are associated with poorer motor competence and reduced physical functioning in children (Vandoni et al., 2024; World Health Organization, 2022).

Similarly, Rusek et al. (2021) reported that children with healthy body composition generally demonstrate superior balance, agility, and locomotor performance compared with children experiencing underweight or obesity. Excess body mass may increase biomechanical constraints during movement, whereas insufficient nutritional intake may reduce muscular strength and endurance, both of which adversely affect motor performance.

Nevertheless, the relatively weak correlation observed in this study indicates that nutritional status alone cannot fully explain children's gross motor ability. Previous studies have consistently shown that motor competence emerges from interactions among nutritional status, habitual physical activity, biological maturation, environmental opportunities, and psychosocial influences (Barnett et al., 2022; Robinson et al., 2015).

Combined Relationship between Physical Activity, Nutritional Status, and Gross Motor Ability

The findings revealed that physical activity and nutritional status jointly demonstrated a significant relationship with gross motor ability (R = 0.519), representing a moderate correlation. Together, these variables explained 26.9% of the variance in children's gross motor competence, suggesting that approximately three-quarters of motor development is influenced by additional factors not examined in this study.

These findings support the conceptual framework proposed by Stodden et al. (2008), which emphasizes that motor competence develops through continuous interactions among physical activity, physical fitness, biological characteristics, and health-related factors. Nutritional status provides the physiological foundation necessary for growth and muscle function, whereas physical activity supplies the repeated movement experiences required to refine motor skills.

Recent systematic reviews further demonstrate that children who simultaneously maintain adequate nutritional status and engage in regular moderate-to-vigorous physical activity consistently achieve higher levels of motor competence than children with only one favorable condition (Barnett et al., 2022). Motor competence is strongly associated with both health-related fitness and physical activity throughout childhood, highlighting the interconnected nature of these variables Kokstejn et al., 2025; Lee et al., 2020).

Moreover, Casu et al. (2020) reported that interventions integrating physical activity promotion with nutritional improvement produce greater gains in motor competence than interventions targeting either factor independently. This finding suggests that comprehensive school-based health promotion programs may provide the greatest benefits for children's motor development.

Although physical activity and nutritional status together explained approximately one-quarter of the variance in gross motor ability, the remaining unexplained variance indicates that other determinants—including biological maturation, sex, genetic predisposition, socioeconomic status, parental involvement, quality of physical education, school facilities, and neighborhood environment—also contribute substantially to children's motor development (Barnett et al., 2022; Robinson et al., 2015; World Health Organization, 2020). Therefore, future research should adopt multidimensional models incorporating these additional variables to better explain variations in gross motor competence among elementary school children.

CONCLUSIONS

Based on the findings of this study conducted among elementary school students in Lembah Melintang District, physical activity was significantly associated with gross motor ability (R = 0.404), explaining 16.3% of the variance, whereas nutritional status demonstrated a weaker but still significant association (R = 0.334), accounting for 11.2% of the variance. When analyzed simultaneously, physical activity and nutritional status were moderately associated with gross motor ability (R = 0.519), jointly explaining 26.9% of the variance. These findings indicate that both variables contribute to children's gross motor development, although approximately 73.1% of the variance remains attributable to other biological, environmental, psychosocial, and behavioral factors not examined in this study.

The interpretation of these findings should be considered in light of several limitations. Physical activity was assessed using the Physical Activity Questionnaire for Older Children (PAQ-C), a validated self-report instrument; however, self-reported physical activity is susceptible to recall and social desirability bias, which may have influenced the observed associations. Furthermore, the sample was limited to elementary school students from two schools in Lembah Melintang District using a total sampling approach. Although all eligible students were included, the relatively small sample size may have reduced statistical power to detect modest effect sizes and limits the generalizability of the findings to broader populations. In addition, gross motor ability was assessed using a standardized and validated motor assessment instrument, but measurement error and contextual factors cannot be completely excluded.

Future studies should employ larger and more diverse samples based on an a priori statistical power analysis to improve the precision and generalizability of the findings. Longitudinal or prospective study designs are recommended to establish temporal precedence and better understand causal pathways between physical activity, nutritional status, and gross motor development. Moreover, objective measures of physical activity, such as accelerometers, combined with standardized assessments of gross motor ability, are recommended to strengthen measurement validity and reduce bias.

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