



The Relationship Between Cardio-Respiratory Endurance (Vo2max) and Student Achievement

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Abstract

This study aimed to examine the relationship between cardiorespiratory endurance ($VO_2\text{max}$) and Physical Education, Sports, and Health (PJOK) learning outcomes among tenth-grade students of SMKN 3 Singaraja in the 2025/2026 academic year. This study employed a quantitative correlational design involving 74 students from the Visual Communication Design (DKV) program. Cardiorespiratory endurance was estimated using a 2.4 km running test, while PJOK learning outcomes were obtained from students' final semester grades. Data were analyzed using the Pearson Product Moment correlation after meeting the normality assumption. The results revealed a significant positive relationship between $VO_2\text{max}$ and PJOK learning outcomes ($r = 0.242$, $p < 0.05$), indicating a low correlation. The coefficient of determination showed that $VO_2\text{max}$ contributed 5.86% to the variation in PJOK learning outcomes. It can be concluded that better cardiorespiratory endurance tends to be associated with better PJOK learning outcomes, although its contribution is relatively small.



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Introduction

Physical fitness is an important component related to students' physical readiness to participate in learning activities at school. A good level of physical fitness enables students to have better stamina and physiological capacity, allowing them to maintain concentration and active engagement throughout the learning process. In the context of Physical Education, Sports, and Health (PJOK), physical fitness is not only a learning objective but also serves as a supporting factor for achieving learning outcomes. PJOK instruction based on physical activity requires sustained physical engagement; therefore, physical fitness is a critical prerequisite for students to participate in learning effectively and optimally (Bailey, Hilman, Arent, & Petitpas, 2020; Kenney, Wilmore, & Costill, 2022).

The Physical Education and Health (PJOK) curriculum emphasizes the holistic development of students, encompassing physical, psychomotor, cognitive, and affective aspects. Student success in PJOK is determined not only by theoretical mastery of the material but also by physical readiness to participate in practical learning activities that require direct physical engagement. Students with good physical fitness are generally better able to maintain active participation, understand motor skills, and demonstrate positive attitudes and high engagement during the learning process. Thus, physical fitness plays a strategic role in supporting the quality of the learning process as well as the comprehensive achievement of Physical Education learning outcomes.

Physical fitness has several components, one of which is cardiorespiratory endurance. In this study, physical fitness was limited to the component of cardiorespiratory endurance, represented by an estimate of $VO_2\text{max}$. This component was selected because it is directly related to the ability of the cardiovascular and respiratory systems to continuously supply oxygen during physical activity, thereby playing a crucial role in supporting dynamic Physical Education and Health (PJOK) learning activities of moderate to high intensity. Good cardiorespiratory endurance allows students to maintain the intensity of learning activities for longer periods without experiencing excessive fatigue, which ultimately impacts their engagement in learning and their achievement of Physical Education learning outcomes (Suryadi, 2022).

Various studies indicate that the level of physical fitness among adolescents in Indonesia remains in the moderate to low range. (Yusuf, Kartika, & Saputra, 2020) reported that the majority of high school students have suboptimal levels of physical fitness, a condition that could potentially affect their engagement in Physical Education (PJOK) classes, such as experiencing fatigue quickly and a decline in focus during practical activities. Similar issues may also arise among vocational high school (SMK) students, whose vocational curriculum involves relatively high demands for physical activity and practical training.

Physical fitness, particularly cardiorespiratory endurance, is a key component that supports students' ability to engage fully in the learning process. Good cardiorespiratory endurance allows the body to efficiently supply oxygen to muscle tissues during physical activity, enabling students to maintain activity intensity for longer periods without experiencing excessive fatigue. In addition to benefiting physical performance, cardiorespiratory capacity is also associated with improved physiological function, efficient heart and lung function, and the ability to recover after physical activity. Thus, students with higher VO₂max levels tend to have better physical readiness to participate in various Physical Education and Health (PJOK) learning activities, whether theoretical or practical.

From an educational perspective, learning outcomes in PJOK are influenced not only by teaching strategies and teacher competence but also by students' physical condition. Students with good physical fitness generally exhibit higher levels of concentration, learning motivation, and participation during the learning process. Conversely, low cardiorespiratory endurance can cause students to tire more quickly, be less active in practical activities, and experience a decline in movement quality, which ultimately impacts their learning outcomes. Therefore, measuring VO₂max not only serves as an indicator of physical ability but can also be used as a basis for evaluating students' readiness to effectively participate in PE learning.

VO₂max is a widely used indicator for assessing an individual's aerobic capacity because it reflects the body's maximum ability to utilize oxygen during high-intensity physical activity. VO₂max can be measured using various methods, one of which is the 2.4-km run test (Cooper Test), known for its high validity and reliability and ease of implementation in a school setting. The estimated VO₂max results from

this test provide insight into students' cardiorespiratory fitness levels, making them a valuable tool for evaluating and planning more targeted physical education programs and fitness training.

Although a number of studies have examined the relationship between physical fitness and student academic achievement, research that specifically identifies cardiorespiratory endurance (VO₂max) as the primary indicator of physical fitness and directly links it to Physical Education (PJOK) learning outcomes—which encompass cognitive, psychomotor, and affective aspects—in the context of vocational high school (SMK) students remains limited. The characteristics of vocational high school students, who primarily engage in practical activities and competency-based learning, make physical fitness a factor that requires special attention. Therefore, a scientific study is needed to analyze the relationship between estimated VO₂max—obtained through a 2.4-km running test—and the physical education learning outcomes of 10th-grade students at Singaraja State Vocational High School 3 for the 2025/2026 academic year.

Method

This study employed a quantitative approach with a correlational design, aiming to determine the relationship between physical fitness levels and Physical Education (PJOK) learning outcomes without applying any specific treatment to the research subjects. The independent variable in this study was physical fitness level, limited to the component of cardiorespiratory endurance, while the dependent variable was students' PJOK learning outcomes.

The research subjects were all 10th-grade students at SMK Negeri 3 Singaraja for the 2025/2026 academic year. The sampling technique used was saturation sampling, meaning the entire population served as the research sample. The study was conducted during the even semester of the 2025/2026 academic year at SMK Negeri 3 Singaraja.

Physical fitness levels were measured using a 2.4-km run as a field fitness test to estimate VO₂max values, rather than as a direct measurement of aerobic capacity in a laboratory. The running time was converted into an estimated VO₂max value using the appropriate formula. This approach was chosen because it is practical and has

good validity in estimating cardiorespiratory endurance in a physical education setting (McArdle, Katch, & Katch, 2015; Robianto, Apriantono, & Kusnaedi, 2017)

Physical education learning outcome data were obtained through official school grade records covering cognitive, psychomotor, and affective aspects. These grades were compiled by physical education teachers based on the assessment system in accordance with the school curriculum, thereby ensuring their validity and reliability at the institutional level.

Data analysis was conducted using descriptive analysis to characterize the data, including the minimum, maximum, mean, and standard deviation. Prior to the correlation test, the data were tested for normality using the Kolmogorov-Smirnov or Shapiro-Wilk test with a significance level of 0.05. If the data were normally distributed, the relationship was analyzed using Pearson's product-moment correlation; if the data were not normally distributed, Spearman's rank correlation was used. All data analysis was performed using statistical software.

Result

This study was conducted among 10th-grade students at Singaraja State Vocational High School 3 during the 2025/2026 academic year using a quantitative correlational research design without treatment. All 10th-grade students were included as research subjects (saturation sampling). The students' level of physical fitness was limited to the cardiorespiratory endurance component, which was estimated through a 2.4-km run test and expressed as $VO_2\text{max}$. The use of the 2.4 km run test in this study was intended as a method to estimate students' aerobic capacity, not as a direct measurement of $VO_2\text{max}$; therefore, the results obtained represent the level of cardiorespiratory endurance in a practical context within Physical Education and Health (PJOK) instruction.

The results of the descriptive statistical analysis show that students' estimated $VO_2\text{max}$ values ranged from 20.08 to 38.13 ml/kg/minute, with a mean of 27.62 ml/kg/minute and a standard deviation of 4.80 ml/kg/minute. This variation in values indicates differences in cardiorespiratory fitness levels among students. Meanwhile, Physical Education learning outcomes were derived from end-of-semester grades, which reflect students' achievements in cognitive, psychomotor,

and affective domains in accordance with the school's assessment system. Students' Physical Education learning outcomes ranged from 80 to 87, with a mean of 82.77 and a standard deviation of 1.63, indicating that, in general, students' Physical Education learning outcomes were good and were relatively homogeneous.

Before conducting the correlation analysis, the data were tested for normality using the Kolmogorov–Smirnov test. The test results showed that the VO₂max estimation data and the PJOK learning achievement data were normally distributed ($p > 0.05$), so Pearson's product-moment correlation analysis could be used. The correlation test results showed a correlation coefficient of $r = 0.242$ with a positive relationship and a significance level of $p < 0.05$. These findings indicate a significant relationship between cardiorespiratory endurance and students' PJOK learning outcomes. The coefficient of determination of 5.86% indicates that physical fitness contributes relatively little to the variation in PJOK learning outcomes.

Table 1. Descriptive Statistics of the Research Variables

Variabel	N	Minimum	Maksimum	Mean	Standar Deviasi
Estimated VO ₂ max (ml/kg/minute)	60	20,08	38,13	27,62	4,80
Physical Education Learning Outcomes	60	80,00	87,00	82,77	1,63

Source: Processed research data (2026).

Table 2. Results of the Data Normality Test

Variabel	Test Methods	Sig. (p)	Description
Estimated VO ₂ max	Kolmogorov–Smirnov	0,200	Normally Distributed
Physical Education Learning Outcomes	Kolmogorov–Smirnov	0,156	Normally Distributed

Criteria: Data are normally distributed if the significance level (p) is greater than 0.05.

Table 3. Results of the Pearson Product-Moment Correlation Test

Variabel	r count	Sig. (2-tailed)	Koefisien Determinasi (R ²)	Interpretasi
Estimated VO ₂ max Based on Physical Education Learning Outcomes	0,242	0,041	5,86%	A positive, significant, and low-category relationship

Note: Significant at $\alpha = 0.05$. Tabel 4. Interpretasi Tingkat Hubungan

Correlation Coefficient Interval	Strength of Relationship
0.00–0.199	Very Weak
0.20–0.399	Weak
0.40–0.599	Moderate
0.60–0.799	Strong
0.80–1.000	Very Strong

Based on the r value of 0.242, the relationship between estimated VO₂max and Physical Education learning outcomes falls into the low category.

Table 1 shows that students' estimated VO₂max had a mean value of 27.62 ± 4.80 ml/kg/minute, with a range of 20.08–38.13 ml/kg/minute. Meanwhile, Physical Education learning outcomes had a mean score of 82.77 ± 1.63 , with a range of 80–87, indicating that students' learning outcomes were relatively good and homogeneous.

Furthermore, based on Table 2, the results of the Kolmogorov–Smirnov normality test showed that both the estimated VO₂max and Physical Education learning outcomes had p-values greater than 0.05. Thus, both variables are normally distributed and meet the prerequisites for analysis using the Pearson Product-Moment correlation test.

The correlation analysis results in Table 3 show a correlation coefficient of $r = 0.242$ with a significance value of $p = 0.041$ ($p < 0.05$). These results indicate a significant positive relationship between cardiorespiratory endurance, as estimated by VO₂max, and the physical education learning outcomes of 10th-grade students at SMK Negeri 3 Singaraja. The coefficient of determination of 5.86% indicates that the estimated VO₂max accounts for 5.86% of the variation in Physical Education learning outcomes, while the remaining 94.14% is influenced by other factors outside the scope of the variables under study. Based on the guidelines for interpreting correlation coefficients, a value of $r = 0.242$ falls into the category of a weak relationship.

Discussion

The results of the study indicate that there is a significant relationship between cardiorespiratory endurance and physical education learning outcomes among 10th-grade students at SMK Negeri 3 Singaraja, although the strength of the relationship is relatively low. This positive relationship indicates that students with better cardiorespiratory endurance tend to achieve higher physical education learning outcomes. These findings reinforce the view that physical fitness, particularly cardiorespiratory endurance, plays a role in supporting students' readiness to participate in physical education lessons that require active physical engagement.

Conceptually, cardiorespiratory endurance influences students' ability to maintain the intensity of physical activity during Physical Education lessons.

Students with better aerobic capacity are able to perform physical activities for longer durations without experiencing excessive fatigue, thereby enabling them to pay attention to the teacher's instructions, understand the material, and demonstrate motor skills optimally. This physiological condition enables students to engage more actively and consistently during lessons, which ultimately impacts their achievement of Physical Education learning outcomes. This finding aligns with the view (Kenney, Wilmore, & Costill, 2022) that VO₂max capacity is closely related to the efficiency of the cardiovascular and respiratory systems in supplying oxygen during sustained physical activity.

However, the low coefficient of determination indicates that cardiorespiratory endurance is not the primary factor determining learning outcomes in Physical Education. This can be explained by the nature of Physical Education assessment, which emphasizes not only physical aspects but also cognitive and affective aspects. The assessment system implemented by schools allows students with varying levels of physical fitness to still achieve good learning outcomes as long as they demonstrate an understanding of the material, basic skills, and positive attitudes and participation during the learning process. Thus, physical fitness is more appropriately positioned as a supporting factor for learning readiness, rather than as the sole determinant of learning outcomes in physical education.

These research findings align with previous studies indicating that physical fitness has a positive relationship with student engagement and performance in physical education, though its contribution to learning outcomes is not dominant (Bailey, Hilman, Arent, & Petitpas, 2020; Suryadi, 2022). In the context of vocational high school (SMK) students, who are characterized by vocational learning with relatively high practical demands, physical fitness remains an important factor in supporting the continuity of Physical Education (PJOK) learning activities, even though learning outcomes are influenced by various other factors beyond the students' physical condition.

Conclusion

Based on the results of this study, it can be concluded that there is a significant relationship between physical fitness—specifically, cardiorespiratory endurance—

and academic performance in Physical Education, Sports, and Health (PJOK) among 10th-grade students at SMK Negeri 3 Singaraja. This relationship is positive, indicating that students with better cardiorespiratory endurance tend to achieve better learning outcomes in PJOK as well.

These findings suggest that cardiorespiratory endurance plays a role in supporting students' physical readiness to participate in PJOK lessons that require sustained physical activity. Students with better physical fitness tend to be able to participate in learning activities with lower levels of fatigue, allowing them to participate more effectively in the learning process, both in practical activities and other learning activities.

However, physical fitness cannot be viewed as the sole factor determining PJOK learning outcomes. Learning outcomes in Physical Education are comprehensive achievements because they are influenced by various other factors, such as learning motivation, student engagement, the teacher's instructional approach, as well as aspects of attitude and participation throughout the learning process. Thus, physical fitness serves as a supporting factor that strengthens the Physical Education learning process, rather than as the primary determinant of student learning success..

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