



Correlation of VO₂max Value Versus Physical Activity and Macronutrient Intake in Adolescent Students

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Abstract Cardiorespiratory fitness is a key approach to addressing obesity and cardiovascular issues in adolescents. This study aimed to assess the relationship between physical activity and macronutrient intake with VO₂max in adolescent students. A cross-sectional design was employed, involving 94 students in grade X at SMA Negeri 12 Bandar Lampung. VO₂max was assessed using the Queen's College Step Test, while physical activity levels were evaluated through a 2x24h physical activity level questionnaire. Macronutrient intake was measured using a 2x24h food recall questionnaire. The normality test revealed that the data were not normally distributed. The Spearman test was used to determine the correlation between physical activity, macronutrient intake, and VO₂max. The mean ± standard deviation of the respondents' VO₂max was 34.97 ± 6.77 ml/kg/min. There was a significant correlation between VO₂max and physical activity (p<0.05), but no significant correlation with macronutrient intake (p>0.05). This study concludes that physical activity is correlated with VO₂max, while macronutrient intake is not.

Keywords: VO₂max, Physical activity, Macronutrient intake, Adolescent

INTRODUCTION

Cardiorespiratory fitness refers to the capacity of the heart, lungs, and blood vessels to deliver oxygen to body cells to support physical exertion. A systematic review and meta-analysis have shown that adolescents with inadequate cardiorespiratory fitness face an increased risk of developing obesity and cardiometabolic diseases later in life [1]. One of the key contributors to low cardiorespiratory fitness is a lack of sufficient physical activity. The 2023 Indonesian Health Survey collected data on the physical activity levels of the Indonesian population using an adapted version of the Global Physical Activity Questionnaire (GPAQ) from the WHO. The Indonesian Health Survey data showed that as many as 58.0% of Indonesian adolescents aged 10-14 years are classified as lacking physical activity. Meanwhile, 50.4% of Indonesian adolescents aged 15-19 years are classified as lacking physical activity [2]. The 2018 Basic Health Research revealed that 33.5% of the Indonesian population engages in insufficient physical activity [3]. This figure

is even higher in adolescents, reaching 49.6%. This figure has increased from the 2013 Basic Health Research, which reported that 26.1% of the Indonesians society was physically inactive [4].

In recent years, the relationship between $VO_2\text{max}$, physical activity, and macronutrient intake among adolescent students has garnered increasing attention. Numerous studies have emphasized the importance of these factors in promoting overall fitness and well-being. $VO_2\text{max}$, an indicator of cardiorespiratory endurance, measures the body's ability to utilize oxygen during physical exertion and is influenced by both levels of physical activity and dietary intake. For adolescents, whose bodies are still developing, a balanced intake of macronutrients (protein, fats, and carbohydrates) paired with regular physical activity is essential for optimizing $VO_2\text{max}$ levels and, by extension, fitness [5,6].

Several studies have demonstrated that regular physical activity, particularly endurance-based exercises, directly impacts $VO_2\text{max}$ by improving the cardiovascular and respiratory systems capacity to deliver and utilize oxygen. A study conducted in Lithuania among adolescents aged 11-14 found that lower levels of physical activity demonstrated weaker physical abilities compared to their peers engaged in moderate to vigorous physical activities [7]. The research in Bosnia Herzegovina indicated that children and adolescents with higher cardiorespiratory fitness were more likely to exhibit increased physical activity [8]. Furthermore, a multi-country European study revealed that changes in cardiorespiratory fitness were influenced by participation in specific physical activities, with varying degrees of impact depending on these variables [9].

Several studies in Indonesia have also explored the connection between physical activity and cardiorespiratory fitness. Research conducted on adolescent athletes revealed a significant association between higher levels of physical activity and increased $VO_2\text{max}$, underscoring the importance of regular exercise for enhancing fitness during adolescence [5]. Another study conducted among adolescents aged 12-15 in Cipadang Village, Pesawaran Regency, found a positive correlation between physical activity and $VO_2\text{max}$ [6]. Additionally, the type and intensity of physical activity can affect these outcomes, with high-intensity interval training (HIIT) shown to be particularly effective in improving $VO_2\text{max}$ [10].

Dietary intake, especially macronutrient consumption, also plays a pivotal role in determining $VO_2\text{max}$. Adequate intake of proteins, fats, and carbohydrates are crucial for maintaining energy balance and muscle function, which are vital during physical exertion. Some research, such as that conducted on adolescent athletes, has revealed that diets higher in carbohydrates may support improved $VO_2\text{max}$ levels by providing the necessary fuel for endurance activities [5]. The results of research on 1492 adolescents in eight European cities indicated that greater cardiorespiratory fitness was linked to higher total energy intake in adolescent boys [11]. Similarly, balanced fat intake is important, as it aids in prolonged energy supply during aerobic exercises. Thus, both physical activity and nutrition need to be considered when assessing and improving $VO_2\text{max}$ in adolescents. A study conducted

on adolescents aged 15-18 in Morocco demonstrated a positive correlation between sufficient intake of carbohydrates and proteins and VO₂max. Adolescents who met the recommended levels of carbohydrate and protein intake showed improved physical fitness. This highlights the importance of promoting balanced diets and regular physical exercise among students [12].

his study aimed to examine the relationship between physical activity and macronutrient intake with VO₂max in adolescent students at SMA Negeri 12 Bandar Lampung.

SUBJECT AND METHOD

This study used a cross-sectional study design. The research was conducted on adolescent students at SMA Negeri 12 Bandar Lampung. The dependent variable studied was VO₂max of adolescent students aged 15-18 years. While the independent variables were physical activity and macronutrient intake. The study was conducted in May-October 2023.

The target population in this study were all students at SMA Negeri 12 Bandar Lampung in 2023. Meanwhile, the study population in this study were all students in grade ten (X). Subjects that fit the research needs were determined based on inclusion criteria and exclusion criteria. The inclusion criteria in this study were all adolescent students of SMA Negeri 12 Bandar Lampung in grade X who were active as students in the 2022/2023 academic year. Meanwhile, the exclusion criteria in this study were adolescent students who were inactive and had a history of illness so that they could not take the step test. Based on the Slovin formula, the results obtained were a sample of 94 class X students as a sample.

The type of data collected in this study is primary data. Data collected during the study included VO₂max, physical activity, and macronutrient intake. VO₂max calculation using the Queens College Step Test. The equipment used for the Queens College Step Test includes a stool with a height of 41.3 cm (16.25 inches), a metronome to measure the accuracy of the tempo of step test, a stopwatch and a Queens College Step Test calculation form. Physical activity was measured using the 2x24h physical activity level (PAL) questionnaire, and macronutrient intake using the 2x24h food recall questionnaire and then using nutrisurvey application to measure the results.

Data collection was carried out by researchers with the help three enumerators. Based on the results of the normality test using the Kolmogorov-Smirnov, the data is not normally distributed ($p < 0.05$). The data were then tested statistically using the Spearman test. This study was conducted after obtaining a research ethical clearance letter from the Ethics Committee of the Faculty of Medicine, University of Lampung with number 2914/UN26.18/ PP.05.02.00/2023.

RESULTS

The research was carried out among adolescent students at SMA Negeri 12 Bandar Lampung. Below is a general overview of the findings from the data collection regarding

age, VO₂max, physical activity, and macronutrient intake among the students, which is detailed in Table 1.

Table 1. Distribution of Data on Adolescents Students at SMAN 12 Bandar Lampung

Variables	Mean ± Standard Deviation
Age (yr)	15.11 ± 0.59
VO ₂ max (ml/kg/mnt)	34.97 ± 6.77
Physical Activity Level	1.45 ± 0.19
Energy Intake (kcal)	1785 ± 302
Protein Intake (g)	47.46 ± 13.91
Fat Intake (g)	55.14 ± 19.40
Carbohydrate Intake (g)	183.43 ± 59.38

According to Table 1, the mean age of the respondents is 15.11 ± 0.59 years. The mean VO₂max is recorded at 34.97 ± 6.77 ml/kg/min. The average physical activity level among the respondents is 1.45 ± 0.19. The mean energy intake is 1785 ± 302 kcal, while protein intake has a mean of 47.46 ± 13.91 g. The average fat intake is 55.14 ± 19.40 g, and carbohydrate intake averages 183.43 ± 59.38 g. These dietary intakes were significantly below the recommended levels for their needs.

The results of the normality test conducted using the Kolmogorov-Smirnov method indicated that the VO₂max variable has a p-value greater than 0.05, suggesting that the data are normally distributed. Conversely, the data for physical activity and macronutrient intake showed p-values less than 0.05, indicating that these datasets are not normally distributed. The results of the bivariate analysis on the VO₂max with physical activity and macronutrient intake using Spearman test are presented in table 2

Table 2. Analysis of the Correlation between Physical Activity and Macronutrient Intake with VO₂max in Adolescent Students of SMA Negeri 12 Bandar Lampung

Variables	VO ₂ max
Physical Activity Level	r = 0.420
	p = 0.034
	n = 94
Energy Intake	r=0.243
	p=0.386
	n = 94
Protein Intake	r=0.515
	p = 0.214
	n = 94
Fat Intake	r = -0.207
	p = 0.351
	n = 94

Carbohydrate Intake	r = 0.414 p = 0.406 n = 94
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According to Table 2, the results of the statistical analysis indicate a correlation between physical activity and VO₂max ($p < 0.05$). The correlation coefficient (r) is 0.420, indicating a moderate positive correlation, which suggests that as physical activity levels increase, VO₂max also tend to increase. In contrast, the results of other statistical analyses yielded $p > 0.05$, indicating no significant relationship between macronutrient intake and VO₂max among adolescent students at SMA Negeri 12 Bandar Lampung.

DISCUSSION

The findings of this study indicate a moderate positive correlation between physical activity and VO₂max among adolescent students, emphasizing the significance of regular physical activity in enhancing cardiorespiratory fitness. The correlation coefficient ($r = 0.420$) suggests that as students increase their levels of physical activity, their VO₂max tends to rise correspondingly. This aligns with other research highlighting the vital role of physical activity, particularly endurance training, in improving the cardiovascular system's capacity to utilize oxygen effectively. Consequently, it is essential to encourage students to engage in moderate to vigorous physical activities to foster better cardiorespiratory fitness.

The findings of this study regarding the correlation between physical activity and VO₂max are consistent with research indicating that higher levels of physical activity are significantly associated with increased VO₂max in adolescents. [5,6]. The results of research on adolescent fitness in Surabaya show that a significant correlation between physical activity with physical fitness [13]. The study conducted in Lithuania among adolescents aged 11-14 found that lower levels of physical activity demonstrated weaker physical abilities compared to their peers engaged in moderate to vigorous physical activities [7]. The research in Bosnia Herzegovina indicated that children and adolescents with higher cardiorespiratory fitness were more likely to exhibit increased physical activity [8]. In contrast, another study suggested that healthcare practitioners should recognize that promoting increased physical activity among inactive and underweight children and adolescents will lead to more significant improvements in VO₂max compared to their active and overweight or obese peers [14]

On the other hand, the results show no significant correlation between macronutrient intake with VO₂max. Adequate macronutrient intake is typically associated with improved physical performance and energy balance. This research is not in line with other studies. Several studies have demonstrated that higher carbohydrate and protein intake support endurance performance and muscle function, which are crucial for aerobic fitness. A study

examining cardiorespiratory fitness among adolescents aged 15-18 in Morocco found a positive correlation between sufficient carbohydrate and protein intake and $VO_2\text{max}$. [12]. The research on adolescents have revealed that diets higher in carbohydrates may support improved $VO_2\text{max}$ levels by providing the necessary fuel for endurance activities [5]. Additional findings from a study involving 1,492 adolescents across eight European cities indicated that greater cardiorespiratory fitness was linked to increased total energy intake among adolescents [11].

However, in this study, macronutrient intake did not significantly affect $VO_2\text{max}$, possibly due to variations in dietary habits, or inadequate overall consumption of the recommended macronutrient levels. The average macronutrient intake reported in this study was lower than the recommended values, which may explain the lack of correlation. This insufficiency in macronutrient intake could have undermined the potential impact of diet on cardiorespiratory fitness, suggesting that simply consuming macronutrients may not be enough if the intake does not meet energy requirements [12].

It is also important to consider that factors such as the quality of macronutrients consumed and the timing of intake could play a role in affecting fitness outcomes. Some research has shown that the type of carbohydrates and proteins consumed, as well as when they are ingested, can influence energy utilization during physical activity and recovery processes. Research conducted on adolescent students in New Zealand revealed that improvements in cardiorespiratory fitness were associated with healthier dietary patterns, indicating that both aspects should be addressed as part of a comprehensive lifestyle intervention [15].

Overall, the results of this study emphasize the significance of physical activity in improving $VO_2\text{max}$, while also pointing to potential gaps in nutrition that may need to be addressed for better fitness outcomes in adolescents. The findings underscore the necessity of incorporating both exercise and nutrition education into school health programs to enhance overall fitness and mitigate future health risks linked to inadequate cardiorespiratory fitness.

CONCLUSION

In summary, this study reveals a noteworthy positive correlation between physical activity and $VO_2\text{max}$ among adolescent students, highlighting the significance of regular exercise in enhancing cardiorespiratory fitness. Conversely, no substantial correlation was observed between macronutrient intake and $VO_2\text{max}$, which may be attributed to inadequate dietary consumption that fails to meet the energy and nutritional requirements of adolescents. These findings indicate that while physical activity is essential for improving fitness levels, it is equally important to consider appropriate dietary intake, particularly regarding macronutrients, to optimize health outcomes in this population.

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