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The Relationship between Body Mass Index (BMI) and VO_2Max in Sports Students

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Abstract

Background: Sports students, often also athletes and coaches, require optimal physical condition and fitness for peak performance and achievement. Maintaining fitness minimizes health risks and boosts exercise efficiency. VO_2Max, the maximal oxygen uptake during intense exercise, is a key cardiovascular fitness indicator closely tied to muscle work capacity. Elevated Body Mass Index (BMI) and excess fat can impair cardiac function, reduce cardiac output, and hinder oxygen uptake, leading to lower VO_2Max. This study focuses specifically on trained, active sports students, distinguishing it from prior research on general student populations.
Objectives: To examine the relationship between BMI and VO_2Max in sports students.
Methods: This quantitative descriptive study used an observational analytic design. The study involved a total of 30 subjects active university students (19-22 years) were purposively sampled. BMI was measured with TANITA BC-545N, and VO_2Max with the 12-minute Cooper test. Data analysis included descriptive statistics, Shapiro-Wilk normality test, and Pearson correlation.
Results: Mean BMI was 21.84 ± 2.52 kg/m^2. Most participants (70%) had normal BMI; 10% were underweight, 20% overweight. Mean VO_2Max was 45.13 ± 4.93 mL/kg/min. Participants VO_2Max, 53% were "good" and 23.5% "excellent".Normality test with Shapiro Wilk, *p value* BMI = 0.374 and *p value* VO2Max = 0.345 it mean (p> 0.05) then the data was normally distributed so that it was continued with parametric test is the Pearson Correlation test. A Pearson correlation showed a statistically significant negative relationship between BMI and VO2 Max (r = -0.372; p = 0.043), indicating a weak but inverse correlation.
Conclusion: A significant negative relationship exists between BMI and VO_2Max in sports students. Effective BMI management is crucial for preserving optimal cardiovascular fitness in this group.

Keywords: BMI, VO_2Max, Sport Student.

INTRODUCTION

Sports students are frequently expected to maintain an ideal physique and high levels of physical fitness. This is crucial for their performance and achievements. Many of these students also hold statuses as athletes and coaches in addition to their academic roles. Optimal body condition and fitness are vital for supporting their academic success and can minimize susceptibility to illness. Given their demanding physical activity, an ideal and fit body significantly contributes to more efficient exercise. For student-athletes, maintaining an ideal and fit body is paramount for supporting their athletic achievements (Chen et al., 2024)

According to the WHO, BMI is used to classify nutritional status, with BMI <18.5 indicating underweight, 18.5-24.9 indicating normal nutrition, and BMI >30 indicating obesity. Body Mass Index (BMI) is a straightforward method for monitoring adult nutritional status, especially regarding underweight and overweight (obesity). Being underweight can increase the risk of disease.

Previous research supports that obesity restricts various activities, leading to lower physical fitness levels. Obesity can impose an excessive burden on heart function, potentially leading to heart failure. High body fat in obese individuals creates an additional burden and hindrance to cardiorespiratory function. This functional decline impacts oxygen uptake for intracellular metabolism, particularly in musculoskeletal cells. Due to disproportionate fat accumulation, the musculoskeletal system may not receive optimal oxygen during exercise. This is evident in the low VO2max values observed in obese individuals (So and Choi, 2010).

If an individual's BMI is high, falling into the overweight or obese categories, there will be an increase in body fat tissue. An increase in body fat tissue can reduce the physiological function of the heart due to ventricular wall thickening, leading to decreased cardiac output. This results in less blood being pumped, and consequently, less oxygen circulating to the muscles. Increased fat tissue is also associated with reduced body function, which can impact VO2max (Gantarialdha et al., 2024)

Jones and Nzekwu's research, involving 373 patients, revealed a significant negative effect of BMI on lung volume or expiratory reserve volume (ERV). Fung et al. demonstrated a positive correlation between BMI and respiratory function in 1586 healthy children.

VO_2Max represents the maximum volume of oxygen consumed per minute during maximal exercise. Measuring VO_2Max is useful for assessing an individual's fitness status, particularly concerning cardiovascular risk (Shah et al., 2022). VO_2Max levels are related to an individual's muscle work capacity, meaning greater exertion requires more oxygen consumption.

This is influenced by muscle quantity and mass; larger muscle mass under heavy workload leads to a greater increase in oxygen uptake. The VO_2Max value can be represented through the maximum oxygen volume, also known as VO_2Max (Antunes et al., 2022).

Good physical fitness includes excellent aerobic capacity, which can be assessed by VO2 Max. To achieve a good VO2 Max value, one's BMI should be maintained at an ideal level through proper diet and physical activity with appropriate frequency and intensity.

Based on prior research, this study aims to investigate the influence of BMI on VO2 Max in sports students. A key distinction from previous studies is that much of the prior research focused on the general student population and untrained individuals. In contrast, this study utilizes sports students as subjects, who frequently engage in physical activity and are trained.

This study is important for advancing sports science and encouraging sports students to maintain an ideal BMI to achieve optimal cardiorespiratory fitness—measured by VO_2Max. A well-conditioned body ensures that the physical health and performance of sports students remain at a high level, thereby enhancing athletic achievements and reducing the risk of injury

METHODS

This study is a quantitative descriptive research employing an observational analytic method. The research subjects were selected using a purposive sampling technique, involving 30. The inclusion criteria in this study were active students aged 19-22 years, willing to participate voluntarily and had no history of cardiorespiratory disease. The exclusion criteria in this study were students who withdrew and were sick during the study. The study was conducted at the athletic field of Universitas Negeri Surabaya in October 2024, focusing on the impact of Body Mass Index (BMI) on aerobic capacity (VO2Max). The independent variable in this study is body mass index, while the dependent variable is VO2Max. Data collection involved the 12-minute Cooper test for aerobic capacity and the TANITA BC-545N for body composition. Data were analyzed using descriptive statistics, normality tests, and Pearson correlation tests to assess the correlation between the two variables.

RESULTS

The descriptive characteristic values present at table 1. The average BMI value of 21.84 ± 2.52 kg/m² indicates that most respondents fall within the normal BMI range. Meanwhile, the average VO_2Max of 45.13 ± 4.93 mL/kg/min suggests that the subjects' aerobic capacity is generally good, consistent with the characteristics of physically active sports students. This is

because the activities of sports students who often train so that their BMI is normal because the energy they enter is formed to build muscle mass as well as their good cardiorespiration because they are often trained as a result of training adaptation.

Table 3.1 Descriptive Characteristics

Variable	Min	Max	Mean ± SD
IMT (kg/m²)	17,36	26	21,84 ±2,52
VO_2Max (mL/kg/min)	36,60	55,76	45,13 ± 4,93

Table 3.2 shows that the majority of participants (70%) were in the normal BMI category, while a small number fell into the underweight (10%) and overweight (20%) categories. This distribution indicates that most of the research respondents had a balanced nutritional status, which is common in a population of sports students. Table 3.3 indicates that most respondents were in the good (53%) and excellent (23.5%) categories for VO_2Max. The remaining individuals were in the fair category (23.5%). This distribution demonstrates that the participants' aerobic capacity was generally in good condition.

Table 3.2 BMI Categories

BMI Category	BMI Category	BMI Category
Underweight	< 18,5	3
Normal	18,5 - 24,9	21
Overweight	≥ 25	6

Table 3.3 VO_2Max Categories

VO_2Max Category	Range (mL/kg/min)	Number of Subjects
Excellent	> 50	7
Good	43 – 50	16
Fair	36 – 42	7

The results of the normality test indicate that both variables have a p-value > 0.05, signifying that the data are normally distributed. Therefore, the Pearson correlation test can be performed for further analysis. the Pearson correlation test, reveals a statistically significant negative relationship between BMI and VO_2Max ($r = -0.372$; $p = 0.043$). The correlation value is at a weak level, indicating that an increase in BMI tends to be associated with a decrease in aerobic capacity, but with a weak correlation in this study.

Table 3.4 Normality Test

Variable	p-value
BMI	0.374
VO_2Max	0.345

DISCUSSION

The research findings indicate a significant negative correlation between Body Mass Index (BMI) and VO_2Max in sports students. A Pearson correlation coefficient of -0.372 shows a low correlation, suggesting that an increase in BMI is associated with a decrease in aerobic capacity. This implies that students with higher BMI tend to have a lower maximal oxygen utilization capacity.

Physiologically, this can be explained by the fact that high body fat mass increases the workload on the cardiovascular system, slows oxygen diffusion, and reduces muscle efficiency during physical activity. Research by Antunes et al. (2022) supports this, stating that excess body fat contributes to reduced aerobic metabolic efficiency (Antunes et al., 2022). A similar study by Fernandes et al. (2021) demonstrated that BMI is negatively correlated with VO_2Max in young athletic populations, with the effect becoming more pronounced when accompanied by visceral fat accumulation. Research by Mak et al. (2021) also showed that lower VO_2Max was found in individuals with non-ideal fat distribution, even within groups with normal BMI.

In the context of sports students, these results are significant because optimal VO_2Max capacity is a crucial component in supporting training and competition performance. Lestari & Supriyadi (2022) noted in their study that structured exercise can significantly reduce BMI and increase VO_2Max, making body composition improvement a key strategy in the development of student-athletes. This finding aligns with the results of Hagen et al. (2023)

Barbosa et al. (2022) who stated that increased body mass, especially fat mass, can reduce oxygen utilization efficiency during physical activity, thereby affecting VO_2Max decline.

Barbosa et al. (2022) affirmed that the accumulation of visceral fat tissue plays a role in decreasing ventilatory efficiency and increasing respiratory resistance during moderate to vigorous intensity activities. This provides a physiological basis for the direct impact of increased body mass on reduced aerobic capacity

A prospective study indicated that VO_2max is a predictor of reduced RHR and long-term health risks in students. Additionally, a study reported a significant negative correlation ($r \approx -0.48$;

$p < 0.01$) between body fat ratio and VO_2max in sports students. These three studies support the focus of this research on the relationship between BMI and VO_2max in active sports students.

This finding is consistent with a meta-analysis by Vasileiadis et al. (2023), which reported a significant negative correlation between body fat percentage and VO_2max ($r = -0.50$ to -0.62; $p < 0.01$) in university students/young adults.

Novak et al. (2022) found that a 5% reduction in visceral fat increased VO_2max by an average of 4.2 mL/kg/min ($p = 0.002$). Barbosa et al (2022) added that increased visceral fat is associated with decreased ventilatory efficiency during intense activity. Therefore, BMI management is crucial for maintaining VO_2Max as a key indicator of cardiovascular fitness. From these results, it can be concluded that controlling BMI is a preventive and curative measure that can be applied to enhance the physical fitness, specifically VO2Max, of sports students.

CONCLUSION

Based on the research findings, it is concluded that a significant negative relationship exists between Body Mass Index (BMI) and VO_2Max in sports students. Although the identified correlation is weak ($r = -0.372$; $p = 0.043$), this finding indicates that an increase in BMI tends to be associated with a decrease in aerobic capacity, or the body's maximal oxygen utilization capability. Therefore, effective BMI management is crucial for maintaining and enhancing VO_2Max capacity, which is a key indicator of optimal cardiovascular fitness for sports students.

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CONFLICT OF INTEREST

The author hereby declares that this research is free from conflicts of interest with any party.

AUTHOR'S CONTRIBUTION

Nurpratiwi Study design and Script Preparation, Susanti and Ayuningtyas study design, Rochmania and Nevangga data collection, Saputri and Azzizah Script Preparation, Solika statiscal analysis.

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