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ORIGINAL ARTICLE

The Relationship between Cardiorespiratory Fitness and Body Mass Index (BMI) in Adolescents of Pirngadi Christian High School, Surabaya

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Abstract:
Background: Cardiorespiratory fitness (CRF) reflects the ability of the heart and lungs to supply oxygen during physical activity. Low CRF values are often associated with an increased risk of metabolic disease, while body mass index (BMI) is an indicator of nutritional status and body composition. Both are closely related to fitness and health in adolescents. Objective: To analyze the relationship between cardiorespiratory fitness and body mass index in adolescents at Pirngadi Christian High School, Surabaya. Methods: This study used an observational analytical design with a cross-sectional approach. Subjects were 30 students (aged 15–18 years) selected using purposive sampling. CRF was measured using a beep test and the results were converted to VO_2Max (ml/kg/min). BMI was calculated from body weight (kg) divided by height squared (m^2). Data analysis used the Pearson correlation test with a significance level of 0.05. Results: The results showed that the average BMI of respondents was 22.5 ± 3.1 kg/m^2 and the average VO_2Max was 38.2 ± 4.5 ml/kg/min. Correlation analysis showed an r value of -0.612 (p = 0.001), indicating a significant negative relationship between BMI and CRF. Conclusion: There is a significant negative relationship between body mass index and cardiorespiratory fitness in adolescents at Pirngadi Christian High School, Surabaya. The higher the BMI, the lower the level of cardiorespiratory fitness.
Keywords: cardiorespiratory fitness; body mass index; VO_2Max; adolescents.

1. Introduction

Obesity has emerged as one of the most pressing global public health challenges of the 21st century. By 2022, more than 1 billion people worldwide were living with obesity (body mass index ≥30) – approximately one in eight adults and approximately 43% of adults were classified as overweight or obese (S. K. Ahmed & Mohammed, 2025). The prevalence of obesity in adults has more than doubled since 1990, and childhood obesity rates have more than quadrupled during that period (S. K. Ahmed & Mohammed, 2025). This dramatic trend has prompted experts to classify obesity as a global epidemic or even a "pandemic" in its scope (Westbury et al., 2023). In other words, excess adiposity is no longer just a concern for a few countries; it now affects populations in nearly every region on the planet.

Physical fitness is the ability to perform daily physical work without compromising biological, psychological, or social health (Gracia- et al., 2023). One component of physical fitness is cardiorespiratory fitness (VO2max). Low cardiorespiratory fitness is positively associated with an overweight and sedentary lifestyle (Li et al., 2022). Cardiorespiratory fitness influences cardiovascular risk factors such as obesity, hypertension, and hypertriglyceridemia. Cardiorespiratory fitness is also used to compare the physical fitness of students, which indicates different nutritional statuses (Malicevic et al., 2022). Cardiorespiratory fitness is a key indicator of health, particularly in preventing cardiovascular and metabolic diseases. The capacity of the cardiovascular and respiratory systems to

distribute oxygen during physical activity significantly determines a person's functional ability and risk of morbidity (Saynor et al., 2020).

In college students, optimal cardiorespiratory fitness supports academic achievement and forms the foundation for maintaining long-term health. As future medical professionals, health students have a moral responsibility to serve as role models in adopting a healthy lifestyle. Adolescence is a crucial period for physical and psychological development that can influence future health status. One important indicator of physical fitness in adolescence is cardiorespiratory fitness (CRF), which reflects the ability of the cardiovascular and respiratory systems to deliver oxygen to tissues during physical activity (Geetha Raghuveer et al., 2020). Body Mass Index (BMI) is widely used to determine nutritional status and identify the risk of obesity.

Increased BMI is associated with decreased oxygen efficiency during aerobic activity. According to data from the Ministry of Health (2018), the prevalence of overweight and obesity among Indonesian adolescents reached 16%, with the highest rates in urban areas. Excess weight impacts decreased cardiorespiratory capacity due to increased mechanical load on the heart and lungs (Mittal et al., 2025). Conversely, a healthy CRF can reduce the risk of cardiovascular disease, improve lung function, and enhance metabolism. Previous research has shown a negative association between BMI and CRF in medical students. However, similar research in adolescents, particularly in Surabaya, is limited. Therefore, this study aimed to analyze the relationship between cardiorespiratory fitness and body mass index in adolescents at Pirngadi Christian High School in Surabaya.

2. Materials and Methods

This study used an observational analytical method with a cross-sectional design. Population: All students at Pirngadi Christian High School in Surabaya. Sample: 30 students aged 15–18 who met the inclusion criteria: general health, no history of heart or respiratory disease, and willingness to participate in a physical examination.

Research instruments:

1. BMI measurement using the formula:

$$BMI = \frac{weight\ (\mathrm{kg})}{height\ (\mathrm{m})^2}$$

   BMI categories refer to the Indonesian Ministry of Health standards (2013).

2. CRF measurements are performed using a 20-meter shuttle run test (beep test). The final value is converted to VO_2Max (ml/kg/min) based on the last level achieved.

Data analysis:

- Data normality was tested using the Shapiro-Wilk test.

Relationships were tested using the Pearson correlation test with a significance level of 0.05.

3. Results

The general characteristics of the respondents showed an average age of 16.8 ± 0.9 years. Nutritional status distribution showed that 10% of students were overweight and 13% were mildly obese.

Variabel	Mean ± SD	Minimum	Maksimum
BMI (kg/m²)	22.5 ± 3.1	17.8	28.6
VO_2Max (ml/kg/menit)	38.2 ± 4.5	29.5	45.8

The correlation test showed a significant negative relationship between BMI and CRF ($r = -0.612$, $p = 0.001$).

The scatterplot showed a decreasing linear pattern, indicating that the higher the BMI, the lower the respondents' VO_2Max values.

4. Discussion

The purpose of this study was to determine the relationship between BMI and cardiorespiratory fitness in adolescents. The results of this study showed a significant negative relationship between BMI and cardiorespiratory fitness in adolescents. This means that increasing body mass tends to decrease aerobic capacity as measured by VO_2Max. Physiologically, increasing body fat causes a decrease in mechanical efficiency during physical activity due to increased 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 decreased aerobic metabolic efficiency.

Cardiorespiratory fitness is closely related to cardiovascular health, metabolic syndrome, and all-cause mortality, making it an important indicator for health assessment (Nes et al., 2024). Low CRF is associated with an increased risk of cardiovascular disease and mortality (Strauss et al., 2021). VO_2max is commonly used as a key indicator for evaluating CRF and serves as a clinically relevant tool for classification (I. Ahmed, 2020). Our results indicate that CRF remains a potent predictor of mortality risk regardless of BMI. These data are physiologically plausible because exercise produces weight loss independent of improvements in markers associated with mortality risk, such as glycemia, insulin sensitivity, cardiovascular function, inflammation, and ectopic fat deposition (Weeldreyer et al., 2025).

In the context of sports students, these results are significant because optimal VO_2max capacity is a crucial component in supporting training and competitive performance. The research, conducted by Laksono et al., 2025 Studies have shown that cardiovascular endurance influences muscle efficiency during repetitive movements such as sprinting, dribbling, and prolonged endurance. This provides a physiological basis for the direct impact of increased body mass on decreased aerobic capacity, cardiac workload, and airway resistance (Raghuveer et al., 2020). Therefore, a structured physical exercise program in schools is highly recommended to improve students' fitness.

Research Limitations

This study is limited in its review, only examining the relationship between BMI and CRF. Therefore, further exploration of the impact of BMI and its potential association with exercise on CRF is warranted.

Directions for Future Research

Future research could explore the molecular impact of physical exercise on cardiorespiratory improvement. Furthermore, the chronic effects of exercise should also be examined to determine how they affect cardiorespiratory-related biomarkers.

5. Conclusions

There was a significant negative correlation between body mass index and cardiorespiratory fitness in adolescents at Pirngadi Christian High School in Surabaya. The higher a person's BMI, the lower their VO_2Max level. These results emphasize the importance of maintaining ideal body weight and regular physical activity from adolescence to improve cardiorespiratory fitness and prevent the risk of cardiometabolic disease in the future.

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Conflict of Interest

The authors declare no conflict of interest.

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