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Body Fat Percentage and Cardiorespiratory Fitness in Female Medical Students: A Cross-Sectional Study

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Abstract

Introduction: Body fat percentage is a crucial determinant of physical fitness, particularly cardiorespiratory endurance, commonly assessed through maximal oxygen uptake (VO_2max). Excess body fat has been linked to impaired aerobic performance. This study aimed to investigate the relationship between body fat percentage and VO_2max among female medical students.

Methods: An analytical observational study with a cross-sectional design was conducted involving 96 female students aged 18–21 years from the Faculty of Medicine, Udayana University. Participants were recruited through purposive sampling. Inclusion criteria included the ability to ambulate independently and a low level of physical activity as determined by the Baecke Questionnaire. Exclusion criteria were balance disorders, physician-diagnosed cardiopulmonary disease, or lower limb injuries. Body fat percentage was estimated using the Relative Fat Mass (RFM) method, and VO_2max was assessed via the Queen's College Step Test (QCT). Data were analyzed using Spearman's rho correlation test.

Results: Analysis revealed a moderate negative correlation between body fat percentage and VO_2max, which was statistically significant ($r = –0.497$; $p < 0.001$).

Conclusion: A moderately strong and significant inverse relationship exists between body fat percentage and VO_2max among female medical students. These findings highlight the importance of maintaining an optimal body composition to support cardiorespiratory fitness in young adults.

Keywords

Physical fitness, body fat percentage, maximal oxygen uptake, Relative Fat Mass, Queen's College Step Test

Introduction

Body composition refers to the proportional distribution of various components within the human body, particularly body fat and fat-free mass, which includes muscle, bone, water, and organs. It is a major determinant of individual health, with body fat emerging as one of the most influential factors affecting both short- and long-term health outcomes.[1] Excess body fat, especially when concentrated in the abdominal region, has been shown to increase the risk of various chronic diseases, such as type 2 diabetes mellitus, hypertension, coronary heart disease, and other metabolic disorders.[2] According to the World Health Organization (WHO), in 2016, more than 800 million individuals worldwide were classified as obese, and this number is projected to continue rising through 2025. In Indonesia, the prevalence of obesity among adults increased from 15.4% in 2013 to 21.8% in 2018, contributing significantly to the burden of degenerative diseases among the productive-age population.[3]

University students, as part of the young adult age group (18–24 years), are particularly vulnerable to increases in body fat percentage due to lifestyle changes characterized by sedentary behavior and unhealthy eating patterns.[4] High academic demands, irregular sleep schedules, increased consumption of high-calorie and high-fat fast foods, and low daily physical activity all contribute to the rising prevalence of obesity among university students.[5,6] Students with low physical activity levels are more likely to have a higher body fat percentage compared to those engaging in moderate to high levels of physical activity.[7] In addition, the prevalence of central obesity in the productive-age population is an important indicator for assessing long-term health risks.[8]

Excessive body fat not only affects physical appearance but also impairs aerobic capacity, typically assessed through maximal oxygen uptake (VO_2max), which represents the maximum volume of oxygen the body can utilize during intense physical activity.[9] A high body fat percentage can hinder cardiovascular and pulmonary function, increase vascular resistance, reduce stroke volume, and lower lung elasticity, resulting in suboptimal oxygen uptake.[10,11] Several studies have found that individuals with higher body fat percentages tend to have lower VO_2max values.[12,13] In addition to body fat, VO_2max is influenced by various other factors, including age, sex, physical activity level, body mass index

(BMI), genetic predisposition, and even geographic variables such as altitude of residence. Hence, maintaining a normal body fat percentage is crucial to supporting cardiorespiratory fitness and overall physical performance.[14]

Given the critical role of body composition in determining fitness capacity, this study aims to analyze the relationship between body fat percentage and VO_2max in students of the Faculty of Medicine, Udayana University. Bali was selected as the study location due to its relatively high obesity prevalence, particularly in Denpasar City, where the rate reaches 15.2%.[3,8] With the growing incidence of obesity among university students, evidence-based interventions are urgently needed to reduce cardiometabolic risk, especially through promotive and preventive approaches within campus settings. This study is expected to provide scientific insight into the association between these two key variables and to serve as a foundation for preventive interventions aimed at improving physical fitness and quality of life among students, while also supporting more structured healthy campus policies.[15]

Methods

This study employed an analytical observational design using a cross-sectional approach. This design was chosen for its ability to describe the relationship between independent and dependent variables at a specific point in time.[16] Cross-sectional studies are widely used in epidemiological research to determine prevalence and assess associations between variables within a defined population.[16] Given the time constraints and the homogeneity of the study subjects, this design was deemed the most appropriate for identifying the association between body fat percentage and VO_2max among medical students.

The study and participant recruitment were conducted at the Faculty of Medicine, Udayana University (FK UNUD), from August 2024 to February 2025. The target population consisted of 96 female students aged 18–21 years who met the inclusion criteria: the ability to walk independently, normal vital signs, low physical activity levels as assessed by the Baecke Questionnaire, and willingness to sign informed consent. Exclusion criteria included a history of cardiopulmonary disease, balance disorders, and lower limb injuries. The sample size was determined using the Lemeshow formula for cross-sectional studies, with an estimated proportion (p) of 0.5, a precision level (d) of 10%, and a Z-score of 1.96 corresponding to a 95% confidence level. Based on these parameters, the minimum required sample size was calculated to be 96 participants, which was adopted for this study.

Body fat percentage was assessed using the Relative Fat Mass (RFM) method, calculated based on height (measured with a stadiometer) and waist circumference (measured with a tape measure).[15] The RFM formula for females is: 76 – (20 × height [m] / waist circumference [m]). The RFM values were then categorized into five groups: essential fat (10–13%), athletes (14–20%), fitness (21–24%), average (25–31%), and obese (>32%). VO_2max was estimated using the Queen's College Step Test (QCT), in which participants stepped up and down a 41.3 cm platform for 3 minutes at a pace of 88 beats per minute using a metronome. Post-exercise heart rate was recorded, and VO_2max was calculated using the formula: 65.81 – (0.1847 × heart rate in beats per minute after the test). The VO_2max results were classified into five categories: very poor (<50), poor (50–64), fair (65–79), good (80–89), and excellent (>90). To maintain consistency and minimize intergroup bias, all participants were female FK UNUD students aged 18–21 years. Moreover, physical activity levels were screened using the Baecke Questionnaire to ensure relatively homogeneous conditions in terms of age, sex, and activity level.

Ethical approval was obtained from the Ethics Committee of FK Unud under reference number 0281/UN14.2.2.VII.14/LT/2025. Additionally, formal permission to conduct the study was granted by FK UNUD following a submitted request for data collection.

Data analysis included univariate analysis, normality testing using the Kolmogorov–Smirnov test, and bivariate analysis using the non-parametric Spearman's rho correlation test. Univariate analysis was performed on age, VO_2max, and RFM to assess the distribution of study characteristics. The normality test determined whether the data on body fat percentage and VO_2max were normally distributed. Bivariate analysis examined the relationship between the independent and dependent variables without adjustments. To ensure data integrity, incomplete cases (missing data) were excluded from analysis, and only complete data were included. Additionally, all measurements were performed using standardized procedures across participants to maintain consistency in data collection. All statistical analyses were conducted using SPSS version 27.0.

Results

The following section presents the results of the analysis performed on 96 female students who met the inclusion criteria. The distribution of participant characteristics by age, VO_2max classification, and body fat percentage (RFM) is presented in Table 1.

Table 1. Distribution of Participant Characteristics

Characteristic	Category	Frequency (n)	Percentage (%)
Age	18 years	8	8.3
	19 years	28	29.2
	20 years	40	41.7
	21 years	20	20.8
VO_2max	Very poor	96	100
RFM	Essential fat	5	5.2
	Athletes	18	18.8
	Fitness	20	20.8
	Average	32	33.3
	Obese	21	21.9

As seen in Table 1, the participants' age range (18–21 years) conformed to the inclusion criteria. The largest group consisted of 20-year-old students (41.7%), followed by those aged 19 years (29.2%), 21 years (20.8%), and 18 years (8.3%). All participants were categorized as having "very poor" VO_2max. In terms of body fat percentage based on the RFM method, 5 participants (5.2%) fell into the essential fat category, 18 (18.8%) into the athletes category, 20 (20.8%) into the fitness category, 32 (33.3%) into the average category, and 21 (21.9%) into the obese category. Descriptive statistics for both RFM and VO_2max variables are presented in Table 2.

Table 2. Descriptive Statistics of RFM and VO_2max

Statistic	RFM (%)	VO_2max (ml/kg/min)
Valid N	96	96
Mean	25.85	44.32
Median	27.23	44.42
Standard Deviation	6.94	2.47
Minimum	10.58	39.95
Maximum	38.02	49.18

As seen in Table 2, the mean RFM was 25.85%, with a median of 27.23%. RFM values ranged from 10.58% to 38.02%, with a standard deviation of 6.94, indicating considerable variability. The mean VO_2max was 44.32 ml/kg/min, with a median of 44.42 ml/kg/min. The minimum and maximum VO_2max values were 39.95 and 49.18 ml/kg/min, respectively, with a relatively small standard deviation (2.47), suggesting low variability in aerobic capacity among participants. The results of the Kolmogorov–Smirnov normality test for both variables are presented in Table 3.

Table 3. Kolmogorov–Smirnov Normality Test Results

Variable	p-value	Interpretation
Body fat percentage	0.002	Not normally distributed
VO_2max	0.191	Normally distributed

As shown in Table 3, body fat percentage was not normally distributed ($p = 0.002$), whereas VO_2max was normally distributed ($p = 0.191$). Given the non-normal distribution of body fat data, a non-parametric correlation test (Spearman's rho) was used for further analysis. The correlation test results between body fat percentage and VO_2max using Spearman's rho are presented in Table 4.

Table 4. Spearman's Rho Correlation Between Body Fat Percentage and VO_2max

Variable Correlation	Correlation Coefficient (r)	p-value	95% Confidence Interval
Body fat percentage and VO_2max	–0.497	0.001	–0.65 to –0.31

As shown in Table 4, the Spearman's rho test revealed a moderate negative correlation between body fat percentage and VO_2max ($r = –0.497$, $p = 0.001$). This indicates that an increase in body fat percentage is associated with a decrease in VO_2max. The 95% confidence interval (–0.65 to –0.31) suggests a precise estimate of the correlation strength. Since the p-value is less than 0.05, the correlation is considered statistically significant.

Discussion

Participant Characteristics

The findings of this study revealed a significant inverse relationship between VO_2max and body fat percentage ($r = –0.497$; $p < 0.001$). This negative correlation indicates that female medical students at Udayana University (FK UNUD) with higher body fat percentages tend to have lower VO_2max levels. This result is consistent with previous studies showing that excess body fat can impair both respiratory and cardiovascular function, thereby reducing the body's ability to uptake and utilize oxygen during intense physical activity.[10,17]

Several physiological mechanisms may contribute to this decline in VO_2max among individuals with higher fat percentages. Excess adiposity increases the cardiac workload, reduces stroke volume, and elevates peripheral resistance.[9,18] The accumulation of adipose tissue also compromises lung capacity and elasticity, ultimately restricting maximal oxygen uptake.[19] Additionally, adipose tissue is metabolically less active than muscle tissue, leading to reduced metabolic efficiency in individuals with higher fat mass.[11] As a result, those with greater fat percentages consume less oxygen per unit of active muscle mass. Furthermore, diminished aerobic capacity is linked to elevated risk of metabolic diseases, reduced physical performance, and earlier onset of muscle fatigue.[20]

These findings also support the hypothesis that physical inactivity, common among university students due to academic demands, contributes to increased fat accumulation and reduced VO_2max.[4] The frequent consumption of high-calorie fast food combined with a sedentary lifestyle leads to higher body fat percentages among students, which adversely affects cardiorespiratory fitness.[5,6]

Young adulthood (ages 18–21) is a transitional physiological phase that is particularly vulnerable to body composition changes triggered by unhealthy lifestyle choices. Age plays an important role in shaping the study results.[21] Even within this productive age group, a physically inactive lifestyle can accelerate the decline in physical fitness, despite the theoretical peak of VO_2max typically occurring between the ages of 20 and 30 years.[22]

This study has several limitations. First, the cross-sectional design precludes causal inferences between body fat percentage and VO_2max. Second, potential confounding variables such as daily physical activity levels, caloric intake, and psychological stress were not measured, despite their potential influence on VO_2max. Third, the restricted sample—limited to female medical students at FK UNUD—limits the generalizability of the findings to broader

populations. Nonetheless, this study underscores the importance of maintaining healthy body fat levels to improve or preserve cardiorespiratory fitness among young adults, particularly students.

Relationship Between Body Fat Percentage and VO_2max

The relationship between body fat percentage and VO_2max can be explained through multiple physiological, metabolic, and mechanical mechanisms. Individuals with higher fat percentages accumulate more adipose tissue, which is metabolically inactive, thereby reducing the body's capacity to effectively uptake, transport, and utilize oxygen.[23,24] This additional fat mass places a greater burden on the heart, increases basal energy expenditure, and reduces oxygen availability for working muscles during physical exertion.[14] Several studies have reported that VO_2max is influenced by the amount of metabolically active tissue (i.e., muscle), while excessive adipose tissue negatively affects this metabolic ratio.[9] Consequently, a higher body fat percentage increases the physiological workload required to maintain homeostasis during physical activity, ultimately lowering VO_2max values.[1,15]

Physiologically, external factors such as physical activity, dietary intake, and lifestyle habits also play essential roles. Excess energy intake from high-calorie and high-fat foods, when not balanced by adequate physical activity, leads to an energy surplus stored as body fat.[25] This imbalance contributes to increased fat percentage and decreased VO_2max.[6]

In the present study, all participants were classified in the “very poor” VO_2max category, and over 55% had body fat percentages falling into the “average” to “obese” categories. This reflects a high level of physical inactivity and a lack of awareness about body composition management among students.[3]

Moreover, this study reinforces the notion that reducing body fat through structured interventions—particularly aerobic exercise and healthy dietary practices—can significantly enhance VO_2max.[26,27] Maintaining a body fat percentage within the “fitness” or “athlete” range improves physical performance, reduces cardiometabolic risk, and promotes longer healthspan.[28,29]

Accordingly, efforts to improve physical fitness among university students should not only focus on increasing the intensity and frequency of physical activity but also emphasize nutrition education and healthy weight management. Recommended interventions include moderate-intensity aerobic exercises, such as jogging or cycling, for a minimum of 150 minutes per week as per WHO guidelines. Furthermore, campuses should implement health promotion programs by providing accessible sports facilities, balanced nutrition education, and regular body composition screenings.

Conclusion

This study demonstrated a significant negative correlation between body fat percentage and VO_2max among female medical students at Udayana University. Higher body fat percentages were associated with lower VO_2max levels. These findings highlight the importance of adopting a healthy lifestyle, including regular aerobic exercise and proper nutritional management, such as reducing the intake of high-fat foods, in order to maintain optimal cardiorespiratory fitness.

By implementing healthy lifestyle practices, students can not only improve their VO_2max but also reduce their risk of cardiovascular diseases and enhance their long-term quality of life. These efforts contribute to achieving optimal physical fitness and promoting better overall health outcomes.

Future research is recommended to explore additional factors influencing VO_2max. Furthermore, campus health programs that promote regular physical activity and nutrition education should be developed and institutionalized to support sustainable improvements in student fitness and well-being.

Author Contribution

I Gusti Agung Wika Indirayani RS conceived and designed the study, performed data collection, and drafted the manuscript. Indah Pramita contributed to data analysis and interpretation. M. Widnyana assisted in methodological supervision and manuscript revision. Made Hendra Satria Nugraha provided critical review and academic guidance. All authors read and approved the final version of the manuscript.

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Conflict of Interest Statement

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The authors declare no conflicts of interest related to this work.

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Ethics Statement

Ethical approval was obtained from the Ethics Committee of the Faculty of Medicine, Udayana University (Reference No. 0281/UN14.2.2.VII.14/LT/2025). Formal permission to conduct the study was granted by the Faculty of

Medicine, Udayana University, following submission of a data collection request. Written informed consent was obtained from all participants prior to data collection.

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