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Research Article

CORRELATION OF BODY COMPOSITION PARAMETERS WITH CARDIOVASCULAR FITNESS IN ADULTS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Cardiorespiratory fitness is widely recognized as one of the strongest independent predictors of cardiovascular health, overall functional capacity, and long-term mortality, while excess adiposity remains a major modifiable contributor to the global burden of cardiometabolic diseases, including hypertension, type 2 diabetes mellitus, dyslipidemia, and cardiovascular disease. Although body mass index (BMI) is commonly used to assess obesity, it does not distinguish between fat mass and lean body mass and may not adequately reflect the distribution of body fat, particularly central adiposity, which has been shown to exert a greater adverse effect on metabolic and cardiovascular health. Consequently, additional body composition measures such as body fat percentage, waist circumference, and waist–hip ratio have gained importance as indicators of obesity-related health risk. Understanding the relationship between these body composition parameters and cardiovascular fitness may provide valuable insights for early risk identification and preventive health strategies. Therefore, this cross-sectional analytical study was conducted among 168 apparently healthy adults to examine the correlation between body composition parameters and cardiovascular fitness and to determine which adiposity measures were most strongly associated with predicted maximal oxygen uptake (VO2max), a widely accepted indicator of cardiorespiratory fitness. Anthropometric measurements including BMI, waist circumference, waist–hip ratio, and body fat percentage were obtained, while cardiovascular fitness was assessed using a validated submaximal step test to estimate predicted VO2max. The analysis demonstrated significant inverse correlations between predicted VO2max and several measures of adiposity, with body fat percentage showing the strongest negative association ($r \approx -0.55$), followed by waist circumference ($r \approx -0.48$) and BMI ($r \approx -0.42$). Furthermore, predicted VO2max progressively declined across increasing BMI categories, indicating that individuals with higher levels of adiposity generally exhibited poorer cardiovascular fitness. Multivariable regression analysis revealed that body fat percentage remained an independent predictor of cardiorespiratory fitness even after adjustment for age, sex, and physical activity levels, highlighting its particular importance in determining functional cardiovascular capacity. These findings suggest that higher adiposity, especially increased body fat percentage and central fat accumulation, is associated with reduced cardiovascular fitness among adults. The results underscore the potential value of incorporating simple body composition assessments into routine health evaluations to identify individuals who may benefit from targeted lifestyle modification, exercise promotion, and weight-management interventions aimed at improving cardiovascular fitness and reducing future cardiometabolic risk. However, because of the cross-sectional nature of the study, causal relationships cannot be established, and longitudinal studies are required to determine whether changes in body composition directly translate into improvements in cardiorespiratory fitness over time.

Keywords: Body composition; Body fat percentage; Waist circumference; VO2max; Cardiorespiratory fitness; BMI.

INTRODUCTION

Cardiorespiratory fitness, commonly quantified by maximal oxygen uptake (VO2max), represents the integrated ability of the respiratory, cardiovascular, and skeletal muscle systems to transport, deliver, and utilize oxygen during sustained physical activity (1). It is widely recognized as one of the most important indicators of overall health and functional capacity and has been consistently identified as a powerful independent predictor of cardiovascular disease, metabolic disorders, and all-cause mortality (2). Numerous epidemiological studies have demonstrated that individuals with lower levels of cardiorespiratory fitness experience substantially greater risks of adverse cardiovascular outcomes and premature death, often independent of traditional risk factors such as hypertension, dyslipidemia, smoking, and obesity. In parallel, excess adiposity has emerged as a major public health concern due to its strong association with cardiometabolic diseases, including type 2 diabetes mellitus, hypertension, coronary artery disease, and metabolic syndrome (3,4). Increased body fat accumulation can negatively influence cardiovascular fitness through multiple mechanisms, including increased metabolic demand, impaired ventilatory efficiency, reduced physical activity participation, insulin resistance, endothelial dysfunction, and chronic low-grade systemic inflammation (5). Body composition can be evaluated using simple and practical anthropometric measures such as body mass index (BMI), waist circumference, and waist–hip ratio, as well as by estimating body fat percentage, which provides a more direct assessment of adiposity (6). Among these measures, central adiposity, reflected by waist circumference and waist–hip ratio, has been shown to be particularly important because of its close relationship with cardiovascular and metabolic risk (7). Although direct measurement of VO2max through maximal exercise testing remains the gold standard for assessing cardiorespiratory fitness, it requires specialized equipment, trained personnel, and considerable resources, limiting its widespread use in clinical and community settings. Consequently, validated submaximal exercise protocols such as the Queen's College Step Test offer practical and reliable alternatives for estimating VO2max in large populations. The relationship between fitness and adiposity continues to attract considerable scientific interest, particularly regarding the relative contributions of physical fitness and body fatness to long-term health outcomes. Despite evidence that both low fitness and excess adiposity independently predict adverse cardiovascular events, relatively few studies have comprehensively examined which body composition parameters demonstrate the strongest association with cardiovascular fitness among apparently healthy adults. Therefore, the present cross-sectional study was undertaken to evaluate the correlation between body composition parameters and cardiovascular fitness in apparently healthy adults. The primary objective was to determine the relationship between predicted VO2max and key measures of adiposity, including body fat percentage, waist circumference, and BMI. Secondary objectives included comparing predicted VO2max across BMI categories, identifying the adiposity measure most strongly associated with cardiovascular fitness, and assessing whether these associations remained independent after adjustment for age, sex, and physical activity levels. The study tested the null hypothesis (H_0) that body composition parameters are not associated with predicted VO2max and the alternative hypothesis (H_1) that greater adiposity is associated with lower cardiorespiratory fitness among apparently healthy adults.

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MATERIALS AND METHODS

This cross-sectional analytical study was conducted in the Department of Physiology at [Institution Name] during the period and was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies. Ethical approval was obtained from the Institutional Ethics Committee and all participants provided written informed consent prior to enrollment. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Apparently healthy adults aged 18–45 years were recruited for participation through voluntary enrollment. Individuals with known cardiovascular, respiratory, neurological, or musculoskeletal disorders that could limit exercise performance, pregnant women, current smokers, and those receiving medications known to influence cardiovascular responses or exercise capacity were excluded. To ensure participant safety and suitability for exercise testing, all individuals underwent pre-participation screening using a standardized questionnaire such as the Physical Activity Readiness Questionnaire (PAR-Q). Body composition assessment was performed using standardized anthropometric techniques. Height and body weight were measured with participants wearing light clothing and no footwear, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). Waist and hip circumferences were measured using a non-stretchable measuring tape, and waist–hip ratio was subsequently derived. Body fat percentage was estimated using [bioelectrical impedance analysis (BIA) / skinfold thickness measurements interpreted through the Durnin–

Womersley equations and converted using the Siri formula], according to established protocols. Participants were categorized into BMI groups based on [World Health Organization (WHO) / Asian-specific] classification criteria. Cardiovascular fitness was assessed by estimating maximal oxygen uptake (VO2max) using the validated Queen's College Step Test, which involved stepping on a 41.3 cm bench for three minutes at a sex-specific cadence under supervised conditions. Recovery heart rate measured immediately after exercise was used to calculate predicted VO2max using established regression equations. All assessments were standardized with respect to testing procedures, instructions, environmental conditions, and time of day to minimize variability. Sample size estimation was based on detecting a correlation coefficient of at least $r = 0.25$ between body composition measures and predicted VO2max, using a two-sided alpha level of 0.05 and statistical power of 80%, yielding a minimum requirement of approximately 123 participants. After allowing for an estimated 10% incomplete or unusable data rate, the target sample size was increased to approximately 135 participants; ultimately, 168 participants were included, thereby improving statistical precision and power. Statistical analyses were performed using. Continuous variables were summarized as mean ± standard deviation or median with interquartile range depending on data distribution, while categorical variables were presented as frequencies and percentages. Associations between body composition parameters and predicted VO2max were examined using Pearson's or Spearman's correlation coefficients as appropriate. Differences in predicted VO2max across BMI categories were assessed using one-way analysis of variance (ANOVA) followed by Tukey's post-hoc test for multiple comparisons. To determine independent predictors of cardiovascular fitness, multivariable linear regression models were constructed with predicted VO2max as the dependent variable and adiposity measures as independent variables, adjusting for age, sex, and physical activity levels. All statistical tests were two-sided, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

Participant characteristics

168 adults participated (78 [46%] female; mean age 29.5 ± 6.2 years). Mean BMI was 24.6 ± 3.4 kg/m² and mean body fat 27 ± 6% (Table 1).

A total of 168 apparently healthy adults participated in the study. The mean age of the participants was 29.5 ± 6.2 years, and 78 individuals (46%) were female. The study population had a mean body mass index (BMI) of 24.6 ± 3.4 kg/m², indicating that a substantial proportion of participants were within the upper normal or overweight range. The average waist circumference was 85 ± 11 cm, while the mean waist–hip ratio was 0.86 ± 0.07, reflecting varying degrees of central adiposity within the cohort. Mean body fat percentage was 27 ± 6%, and the average predicted maximal oxygen uptake (VO2max), an indicator of cardiorespiratory fitness, was 38 ± 7 mL/kg/min. Analysis of the relationship between body composition parameters and cardiovascular fitness demonstrated significant inverse associations across all adiposity measures examined. Predicted VO2max showed the strongest negative correlation with body fat percentage ($r = -0.55$, $p < 0.001$), indicating that individuals with higher levels of body fat tended to have substantially lower cardiorespiratory fitness. Waist circumference also exhibited a moderately strong inverse correlation with predicted VO2max ($r = -0.48$, $p < 0.001$), suggesting that greater central adiposity was associated with reduced aerobic capacity. Similarly, BMI was negatively correlated with predicted VO2max ($r = -0.42$, $p < 0.001$), demonstrating that increasing overall body mass relative to height was associated with declining fitness levels. Waist–hip ratio likewise showed a significant inverse relationship with predicted VO2max, although the strength of this association was comparatively weaker ($r = -0.36$, $p < 0.01$). Overall, the results revealed a consistent pattern whereby increasing adiposity was associated with progressively lower cardiovascular fitness. Among the body composition parameters studied, body fat percentage emerged as the strongest correlate of predicted VO2max, followed by waist circumference, BMI, and waist–hip ratio. These findings suggest that direct and indirect measures of adiposity, particularly body fat percentage and indicators of central fat accumulation, are important determinants of cardiovascular fitness in apparently healthy adults and may serve as useful markers for identifying individuals at risk of reduced aerobic capacity.

Correlation of body composition with fitness

Predicted VO2max correlated inversely with body fat percentage ($r \approx -0.55$, $p < 0.001$), waist circumference ($r \approx -0.48$, $p < 0.001$), BMI ($r \approx -0.42$, $p < 0.001$), and waist–hip ratio ($r \approx -0.36$, $p < 0.01$); see Table 2 and Figure 1.

Fitness across BMI categories

Predicted VO2max declined progressively from the normal-weight to overweight to obese categories ($p < 0.001$; Figure 2). On multivariable regression, body fat percentage remained an independent predictor of predicted VO2max after adjustment for age, sex, and physical activity.

Phytochemical studies:

Table 1: Participant characteristics

Variable	Value (mean ± SD or median [IQR])
Age (years)	29.5 ± 6.2
Female, n (%)	78 (46)
BMI (kg/m²)	24.6 ± 3.4
Waist circumference (cm)	85 ± 11
Waist–hip ratio	0.86 ± 0.07
Body fat (%)	27 ± 6
Predicted VO2max (mL/kg/min)	38 ± 7

Table 2: Correlation of body composition parameters with predicted VO2max

Parameter	Correlation (r) with VO2max	p
Body fat (%)	−0.55	<0.001
Waist circumference (cm)	−0.48	<0.001
BMI (kg/m²)	−0.42	<0.001
Waist–hip ratio	−0.36	<0.01

Figure 1. Body fat percentage (A) and waist circumference (B) versus predicted VO2max

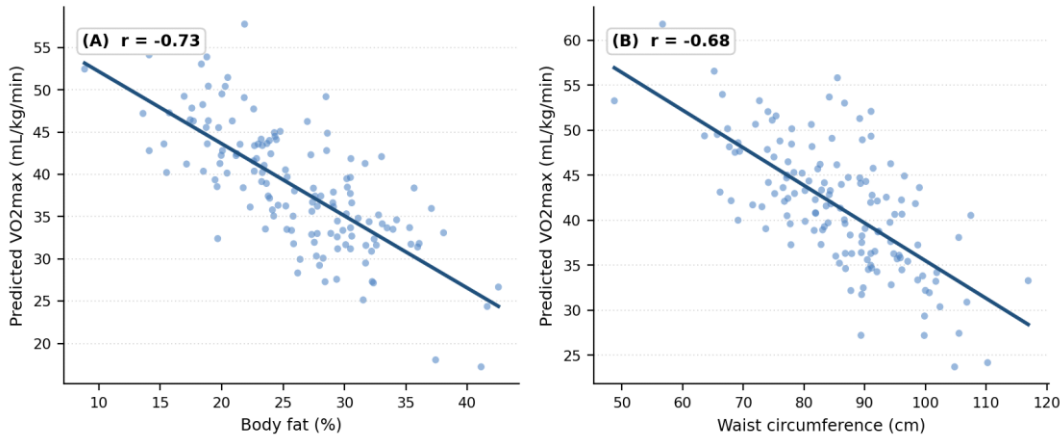
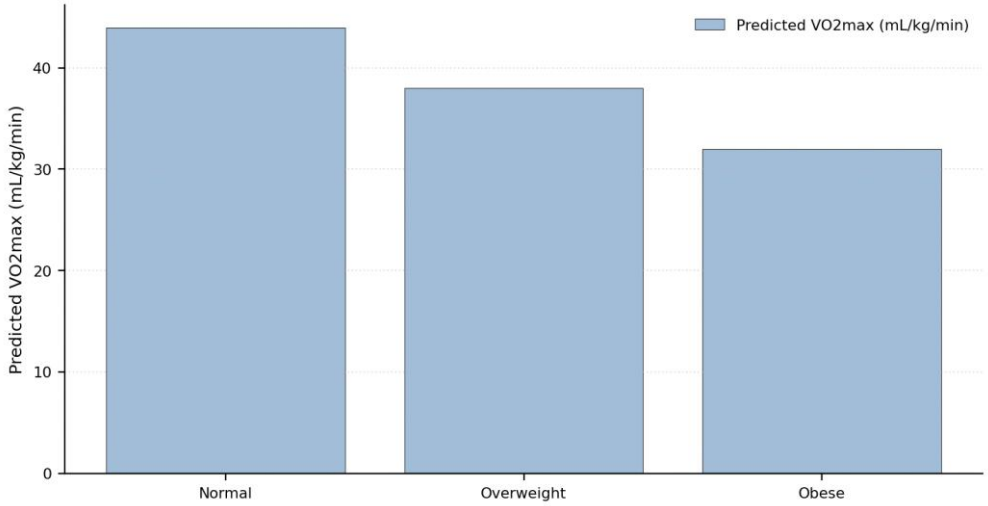


Figure 2. Predicted VO2max across BMI categories



DISCUSSION

In this cross-sectional study of apparently healthy adults, higher levels of adiposity were consistently associated with lower cardiovascular fitness, as reflected by reduced predicted VO2max values. Among the body composition parameters examined, body fat percentage demonstrated the strongest inverse relationship with predicted VO2max, followed by measures of central adiposity such as waist circumference and waist–hip ratio, while body mass index (BMI) also showed a significant but comparatively weaker negative association. Furthermore, predicted VO2max declined progressively across increasing BMI categories, indicating that individuals with greater overall adiposity generally possessed poorer cardiorespiratory fitness. These findings are physiologically plausible and align with current understanding of the adverse effects of excess body fat on exercise performance and cardiovascular function. Increased fat mass elevates the metabolic and mechanical demands of physical activity, requiring greater energy expenditure for movement and reducing exercise efficiency. In addition, excess adiposity, particularly central adiposity, is associated with insulin resistance, endothelial dysfunction, chronic low-grade systemic inflammation, altered autonomic regulation, and impaired ventilatory mechanics, all of which can contribute to reduced aerobic capacity and diminished cardiovascular performance. The observation that body fat percentage was a stronger correlate of predicted VO2max than BMI supports previous evidence suggesting that direct measures of adiposity provide a more accurate representation of metabolic and cardiovascular risk than BMI alone, which cannot differentiate between fat mass and lean body mass. From a clinical and public health perspective, these findings emphasize the value of incorporating simple, inexpensive, and easily obtainable body composition measures, such as waist circumference and body fat estimation, into routine health assessments to identify individuals at risk of reduced cardiovascular fitness. Early identification of such individuals may facilitate targeted interventions including structured exercise programs, weight-management strategies, and lifestyle modification aimed at improving cardiorespiratory fitness and reducing future cardio metabolic risk. The study possesses several strengths, including the use of standardized anthropometric measurements, a validated submaximal fitness assessment protocol, and multivariable analyses adjusting for important confounding factors. Nevertheless, several limitations should be acknowledged. The cross-sectional design prevents determination of causality and temporal relationships between adiposity and fitness. Predicted VO2max derived from a submaximal step test represents an estimate rather than a direct physiological measurement and is therefore less precise than laboratory-based cardiopulmonary exercise testing. Additionally, body fat estimation using bioelectrical impedance analysis or skinfold measurements is subject to method-specific limitations and measurement error. The single-center nature of the study may restrict the generalizability of the findings to other populations, and residual confounding from factors such as dietary habits, habitual physical activity, socioeconomic status, and genetic influences cannot be completely excluded. Future longitudinal studies incorporating direct measurement of VO2max and reference-standard body composition techniques such as dual-energy X-ray absorptiometry (DXA) are warranted to better elucidate causal pathways, dose–response relationships, and the long-term effects of changes in adiposity on cardiovascular fitness.

CONCLUSION

The present study demonstrated that higher levels of adiposity were significantly associated with lower cardiovascular fitness among apparently healthy adults, with body fat percentage and measures of central adiposity showing the strongest relationships with reduced predicted VO2max. Individuals with greater overall and abdominal fat accumulation consistently exhibited poorer cardiorespiratory fitness, and a progressive decline in predicted VO2max was observed across increasing BMI categories. These findings highlight the close relationship between body composition and functional cardiovascular capacity and suggest that excess adiposity may adversely influence aerobic performance through multiple physiological mechanisms, including increased metabolic demand, reduced movement efficiency, impaired respiratory function, and unfavorable cardiometabolic alterations. Importantly, the study indicates that simple, inexpensive, and easily obtainable measurements such as body fat percentage, waist circumference, waist–hip ratio, and BMI can provide valuable information for identifying adults who may be at risk of reduced cardiovascular fitness and its associated health consequences. Incorporating these assessments into routine health evaluations may facilitate early risk stratification and support the implementation of targeted lifestyle interventions focused on increasing physical activity, improving fitness levels, reducing excess body fat, and preventing future cardio metabolic disease. Given the established importance of cardiorespiratory fitness as a predictor of cardiovascular morbidity, mortality, and overall health, strategies aimed at improving fitness should be considered an essential component of preventive healthcare. However, because the present investigation employed a cross-sectional design, causal relationships between adiposity and cardiovascular fitness cannot be established. Therefore, well-designed prospective longitudinal studies and intervention trials are warranted to confirm these associations, clarify

temporal and causal pathways, and determine whether reductions in body fat and central adiposity lead to meaningful improvements in cardiovascular fitness and long-term health outcomes..

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