Profile and Association of Body Fat Percentage, BMI, and VO_2 Max in University Physical Education Students

Perfil y asociación del porcentaje de grasa corporal, el IMC y el VO_2 máx. en estudiantes universitarios de educación física

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Abstract

Introduction: Cardiorespiratory fitness, measured by VO_2 max, is strongly associated with enhanced physical performance during exercise and serves as a key predictor of future health risks.

Objective: This study aimed to assess the profile of body fat percentage, BMI, and estimated VO_2 max in university physical education students and to examine the relationships among these parameters.

Methodology: A total of 25 male and 25 female students were selected through stratified random sampling technique and their anthropometric data were collected with a body composition analyzer machine. Additionally, VO_2 max was assessed through the *Queen's College Step Test*.

Results: The results showed that the average VO_2 max was 37.50 ± 7.72 ml/kg/min for male students and 35.94 ± 4.63 ml/kg/min for female students, with no significant difference between them. A strong negative correlation was observed between %BF and VO_2 max in both groups ($r = -0.749$, $p = 0.001$; $r = -0.531$, $p = 0.006$). Additionally, BMI was significantly inversely correlated with VO_2 max in males ($r = -0.672$, $p = 0.001$) but not in females ($r = 0.037$, $p = 0.861$). A significant positive correlation was also found between BMI and %BF in both groups ($r = 0.855$, $p = 0.001$; $r = 0.470$, $p = 0.037$).

Conclusions: This study concludes that male students in this department exhibited "fair" cardiovascular fitness, while female students fell into the "good" category. Additionally, BMI and %BF showed a negative correlation with VO_2 max.

Keywords

BMI, %BF; Cardiorespiratory fitness; Physical Education and Sports Science; VO_2 max.

Resumen

Introducción: La aptitud cardiorrespiratoria, medida por el VO_2 máx., está fuertemente asociada con un mejor rendimiento físico durante el ejercicio y sirve como un predictor clave de futuros riesgos para la salud.

Objetivo: Este estudio tuvo como objetivo evaluar el perfil del porcentaje de grasa corporal, el IMC y el VO_2 máximo estimado en estudiantes universitarios de educación física y examinar las relaciones entre estos parámetros.

Metodología: Se seleccionaron 25 estudiantes varones y 25 mujeres mediante una técnica de muestreo aleatorio estratificado y se recogieron sus datos antropométricos con un analizador de composición corporal. Además, se evaluó el VO_2 máx mediante el test de pasos del Queen's College.

Resultados: Los resultados mostraron que el VO_2 máx promedio fue de 37,50 ± 7,72 ml/kg/min para los estudiantes varones y de 35,94 ± 4,63 ml/kg/min para las estudiantes mujeres, sin diferencia significativa entre ellos. Se observó una fuerte correlación negativa entre el %BF y el VO_2 máx en ambos grupos ($r = -0{,}749$, $p = 0{,}001$; $r = -0{,}531$, $p = 0{,}006$). Además, el IMC se correlacionó de forma significativa e inversa con el VO_2 máx en los varones ($r = -0{,}672$, $p = 0{,}001$) pero no en las mujeres ($r = 0{,}037$, $p = 0{,}861$). También se encontró una correlación positiva significativa entre el IMC y el %BF en ambos grupos ($r = 0{,}855$, $p = 0{,}001$; $r = 0{,}470$, $p = 0{,}037$).

Conclusiones: Este estudio concluye que los estudiantes varones de este departamento exhibieron una aptitud cardiovascular "regular", mientras que las estudiantes mujeres se ubicaron en la categoría de "buena". Además, el IMC y el % BF mostraron una correlación negativa con el VO_2 máx.

Palabras clave

IMC; %BF; Aptitud cardiorrespiratoria; Ciencias de la Educación Física y el Deporte; VO_2 máx.

Introduction

The Department of Physical Education and Sports Science at Rajshahi University, Bangladesh, is a newly established department where students study human physiology and learn techniques for maintaining a healthy physique, as well as participate in various physical activities to prepare for different sports competitions. To compete at high level and maintain a healthy physique, it is essential to ensure good level of physical fitness. Studies indicate that physical fitness consists of four key components: body composition, muscular strength and endurance, cardiovascular endurance, and flexibility; among these, cardiovascular endurance—measured as VO_2 max—represents the maximum oxygen uptake the body can utilize during exercise (Huldani et al., 2019).

The measurement of VO_2 max is extensively acknowledged as the definitive standard for evaluating both cardiorespiratory fitness and aerobic capacity (Akhtar et al., 2018). Individuals who possess greater physical fitness demonstrate higher VO_2 max levels, which allow them to perform exercise at increased intensity and for extended durations relative to those who are less physically conditioned. Moreover, lower level of cardiorespiratory fitness is associated with poor physical performance and increased risk of mortality (Ekblom-Bak et al., 2019). Researchers suggest that individuals with lower cardiorespiratory fitness are at high risks for CVD death, including hypertension, diabetes and hypercholesterolemia (Grundy et al., 2012).

While many studies on physical fitness use traditional anthropometric indicators such as skinfold thickness, limb circumferences, or bone diameters, this study focused on body composition parameters—specifically BMI and body fat percentage (%BF)—which were measured using bioelectrical impedance analysis (BIA). These methods are widely accepted in university research due to their non-invasive nature, ease of application, and ability to provide consistent estimates of fat mass (Böhm & Heitmann, 2013; Arroyo et al., 2004; Knechtle et al., 2011). BMI and %BF are commonly used body composition indicators that help assess obesity and related health risks. With technological advancements promoting sedentary behavior, modern youth are increasingly physically inactive, which has been linked to elevated adiposity and cardiometabolic complications (Saunders et al., 2014). Recent cross-sectional and meta-analytic findings further emphasize that increased sedentary time and decreased physical activity significantly reduce VO_2 max in young adults, including university students. These studies suggest that prolonged inactivity not only contributes to unfavorable changes in body composition but also directly impairs cardiorespiratory fitness, increasing long-term health risks (Singh et al., 2023; Prince et al., 2024).

In physical education students, variations in cardiorespiratory fitness and body composition are influenced not only by lifestyle but also by the type, frequency, and intensity of physical training undertaken (Moreno-Díaz et al., 2024; Stachoń & Pietraszewska, 2013). For example, endurance-based students may show lower fat percentages and higher aerobic capacity compared to those focused on strength or team sports (Singh et al., 2023; Azmy et al., 2023; Degens et al., 2019). Therefore, understanding the interaction between cardiorespiratory fitness and body composition is essential in such populations.

Previous research suggests a strong relationship between body composition and VO_2 max, indicating that higher body fat levels are associated with lower cardiorespiratory fitness (Gutin et al., 2005). According to the findings of Razak, Maizi, and Muhammad (2013), there exists a notable negative correlation between the VO_2 max levels of students and their %BF, suggests that higher levels of body fatness correspond to lower physical fitness among college students (Razak et al., 2013). A longitudinal study by Pribis et al. (2010) demonstrated a strong inverse relationship between VO_2 max and body fat percentage (%BF) in university students over the period from 1996 to 2008 (Pribis et al., 2010). This inverse association has been consistently supported by more recent investigations involving university populations (Singh et al., 2023; Nur Fiana & Sofiana Putri, 2023). Similarly, a recent study involving young futsal athletes reported a significant negative correlation between %BF and VO_2 max, indicating that individuals with higher body fat levels tend to exhibit lower cardiorespiratory endurance (Kjaergaard et al., 2025). Collectively, these findings underscore the detrimental influence of excess adiposity on aerobic capacity and overall physical fitness.

Despite growing global interest, there is a noticeable gap in the literature examining these variables in Bangladeshi university students, particularly those studying physical education. Several researches indicate that ethnic and regional differences in genetic, fat distribution, body type, dietary habits, and physical activity levels may influence both body composition and VO_2 max (Lesser et al., 2012; Islam et al., 2024; Kjaergaard et al., 2025). Hence, findings from international studies may not fully apply to this population. Therefore, the objective of the current study was to assess and compare the body fat percentage, BMI, and estimated *VO_2 max* of male and female students in the Department of Physical Education and Sports Science at the University of Rajshahi, and to explore the relationship between these variables.

Method

Participants of the study

In this cross sectional study, 50 undergraduate students (25 males and 25 females) were selected from the Department of Physical Education and Sports Science, University of Rajshahi, Rajshahi, using stratified random sampling technique. The study was conducted between January and February 2025. All individuals involved in the current study provided their written consent prior to enrollment, and at the time of the study, all participants were in good health and free from any diseases. Exclusion criteria of this study included post-graduate students, participants from other departments and participants with chronic diseases (e.g., cardiovascular, joint problem, type-2 diabetes, etc.). Menstrual phase was considered for female participants, and testing was avoided during menstruation where possible to minimize hydration-related variation.

Estimation of Body Fat and BMI

The heights of the students were measured while they were standing and barefoot using a stadiometer (Seca, Germany). Their weight, BMI, and body fat percentage (%BF) were estimated through an IN-F500 Body Composition Analyzer (InBody Co., Seoul, South Korea) in accordance with the manufacturer's protocol. The INBody IN-F500 utilizes multi-frequency bioelectrical impedance analysis with four frequencies (5 kHz, 50 kHz, 250 kHz, and 500 kHz), which allows for differentiated estimation of intra- and extracellular fluid, thereby improving the accuracy of segmental assessments of lean mass and body fat percentage. Although the INBody F500 has not been specifically validated in this exact population, BIA devices—including various INBody models—have been widely used in studies assessing body composition in university student populations, demonstrating acceptable levels of reliability and validity for research purposes (Davar, 2015)(Karelis et al., 2013).
Additionally, to ensure valid data collection from the analyzer, pre-measurement guidelines were followed. These included fasting for at least 4 hours prior to measurement, avoiding alcohol or beverages for 12 hours, consuming a minimum of 2 liters of fluid to maintain hydration on the test day, and emptying the bladder before the test (Schiavo et al., 2017).

Calculating VO_2 max through the Queen's College Step Test

Students' cardiorespiratory fitness was evaluated using VO_2 max, which was calculated through the *Queen's College Step Test* protocol. For this assessment, a wooden stepper with a height of 16.25 inches (41.3 cm) was used and the female participants adhered to a stepping rhythm of 22 steps per minute, while male participants followed a rhythm of 24 steps per minute on the stepper. They performed a continuous four-step cycle, described as "up-up-down-down," for a total duration of three minutes. To ensure accurate pace control, a metronome was used to maintain the required step cadence. Additionally, participants received a brief familiarization session before testing to ensure proper rhythm and stepping technique. Participants were instructed to avoid eating and intense physical activity for at least two hours prior to the test to minimize acute physiological fluctuations. However, no controls were applied for prior sleep quality or overall dietary intake, which is acknowledged as a limitation.
Upon completing the test, participants immediately ceased movement, and their pulse rates were recorded for 15 seconds, starting from the 5th second of the recovery period and continuing until the 20th second. Heart rate was measured manually using the radial pulse and a stopwatch, following the

standard *Queen's College Step Test* protocol. These pulse readings were then multiplied by 4 to convert them into beats per minute (bpm). The final VO_2 max value was calculated using the formula proposed by McArdle et al. (1972)(Lokhande et al., 2015).
For male students: VO_2 max (mL/kg/min) = 65.81− [0.1847 × heart rate (bpm)]
For female students: VO_2 max (mL/kg/min) = 111.3− [0.42 × heart rate (bpm)]

Statistical analysis

Statistical analyses were carried out using SPSS version 20. The Shapiro-Wilk test was used to verify the normal distribution of the data, and Levene's test was applied to assess the homogeneity of variances. The Pearson correlation coefficient was utilized to examine associations between variables, while differences between the two groups were analyzed using an independent samples t-test. Effect sizes (Cohen's d for group differences and r^2 for correlation strength) were also reported to evaluate practical significance.
Furthermore, the strength of the correlation coefficients was interpreted based on the classification proposed by (Evans, 1996): very weak (r = 0.00–0.19), weak (r = 0.20–0.39), moderate (r = 0.40–0.59), strong (r = 0.60–0.79), and very strong (r = 0.80–1.0).
A p-value of less than 0.05 was considered statistically significant.

Results

Table 1 summarizes the demographic and anthropometric characteristics of the participants. The average age of male and female students was similar, showing no significant difference. As expected, male students were generally taller and heavier than their female counterparts. According to WHO classification, both groups fell within the normal BMI range, though males were closer to the upper boundary of normal while females were nearer to the lower boundary (Consultation, 2000). Interestingly, female students exhibited a higher percentage of body fat than male students, which is consistent with physiological norms where females typically carry more essential fat. Finally, The mean VO_2 max values of two groups of students were almost closer in the current study.

Table 1. Demographic traits of participants

	Male Students	Female Students
Age (mean ± SD; years)	21.62 ± 1.72	21.8 ± 1.41
Gender (%; N)	50% (25)	50% (25)
Smokers (N)	2	0
Married (N)	0	1
Height (mean ± SD; cm)	166.73 ± 6.04	156.25 ± 7.97
Weight (mean ± SD; kg)	64.72 ± 6.8	47.41 ± 6.72
%BF (mean ± SD)	18.48 ± 5.42	23.37 ± 4.73
BMI (mean ± SD; kg/m²)	23.20 ± 2.88	19.41 ± 1.89
BPM (mean ± SD)	175.68 ± 18.54	161.68 ± 25.09
VO_2 max (mean ± SD; ml/kg/min)	37.50 ± 7.72	35.94 ± 4.63

Notes: %BF = Body fat percentage, BMI = Body mass index, BPM = Beats per minute.

To evaluate the differences in parameters between male and female participants, an independent samples t-test was used; the findings are demonstrated in Table 2. The results showed that the average VO_2 max was 37.50 ± 7.72 ml/kg/min for male students and 35.94 ± 4.63 ml/kg/min for female students, with no significant difference between the groups. The effect size for this difference was small (Cohen's d = 0.25), indicating a minimal practical difference in VO_2 max between sexes.

In terms of BMI, male students had significantly higher values (23.20 ± 2.88) than female students (19.41 ± 1.89). The calculated effect size was very large (Cohen's d = 1.56), suggesting a substantial difference in body mass index between male and female students. Likewise, female students had higher body fat percentages (22.31 ± 3.43) compared to males (15.02 ± 4.83), and this difference also showed a very large effect (Cohen's d = 1.74).

Table 2. 2-tailed p-values from independent samples t-test comparing variables between male and female participants

Variables	Male Students (Mean ± SD)	Female Students (Mean ± SD)	p-value (2-tailed)	Effect Size (Cohen's d)
VO_2 max	37.50 ± 7.72	35.94 ± 4.63	.391	0.25 (small)
BMI	23.20 ± 2.88	19.41 ± 1.89	.001*	1.56 (very large)
%BF	18.48 ± 5.42	23.37 ± 4.73	.001*	1.74 (very large)

At $p < 0.05$, statistical significance is indicated by *

The association between %BF and BMI with VO_2 max, as well as between BMI and %BF among male and female students were investigated in this study using Pearson's correlation analysis. As shown in Table 3, a very strong negative correlation was found between %BF and VO_2 max in male students ($r = -0.749$, $p = 0.001$), and a moderate negative correlation was observed in female students ($r = -0.531$, $p = 0.006$). The proportion of variance explained was 56% for males and 28% for females ($r^2 = 0.56$ and 0.28, respectively). These results indicate that an increase in body fat percentage is associated with a reduction in cardiorespiratory fitness levels. The scatterplots illustrating these relationships are presented in Figure 1.

Table 3. Correlation between %BF and VO_2 max

Group	Pearson's r	p-value	r^2 (Variance Explained)
Male Students	-0.749	0.001	0.56 (56%)
Females Students	-0.531	0.006	0.28 (28%)

Additionally, Table 4 demonstrated that BMI was significantly negatively correlated with VO_2 max in males ($r = -0.672$, $p = 0.001$) but not in females ($r = 0.037$, $p = 0.861$). This represents 45% of variance explained ($r^2 = 0.45$) in males. Scatterplots of these relationships are presented in Figure 2.
Lastly, as presented in Table 5, there was a very strong positive correlation between BMI and %BF in male students ($r = 0.855$, $p = 0.001$) and a moderate positive correlation in female students ($r = 0.470$, $p = 0.037$), with corresponding r^2 values of 0.73 and 0.22, indicating strong and moderate shared variance, respectively, suggesting that an increase in BMI corresponds to higher body fat content in both groups. These associations are visually represented in Figure 3.

Table 4. Correlation between BMI and VO_2 max

Group	Pearson's r	p-value	r^2 (Variance Explained)
Male Students	-0.672	0.001	0.45 (45%)
Female Students	0.037	0.861	0.00 (negligible)

Table 5. Correlation between BMI and %BF

Group	Pearson's r	p-value	r^2 (Variance Explained)
Male Students	0.855	0.001	0.73 (73%)
Female Students	0.470	0.037	0.22 (22%)

Figure 1. Scatterplots illustrating the association between BF% and VO_2 max

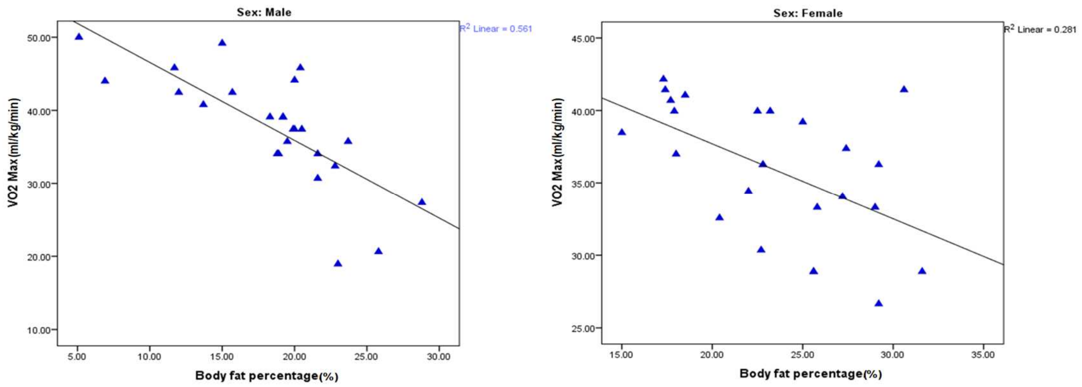


Figure 2. Scatterplots illustrating the association between BMI and VO_2 max

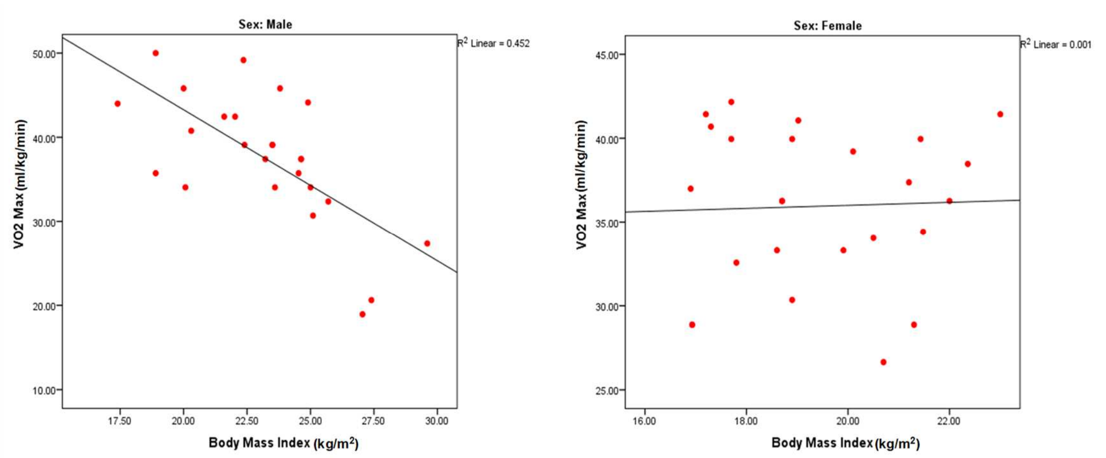
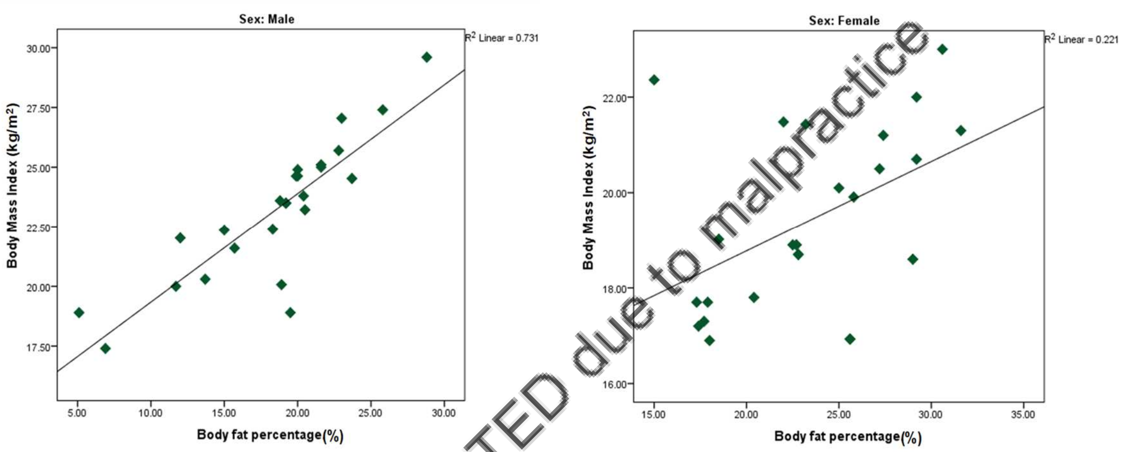


Figure 3. Scatterplots illustrating the association between BMI and %BF



Discussion

VO_2 max is a key measure of cardiorespiratory fitness and also a reliable determinant of future cardiovascular health and overall mortality risks. Research has shown that reduced level of aerobic capacity correlates with a heightened risk of mortality during extended follow-up periods (Ladenvall et al., 2016). In addition, BMI and %BF are also recognized as important indicators of obesity and its associated health risks. Maintaining these parameters is crucial for young individuals to support a fit and healthy lifestyle. In the present study, we conducted an analysis of anthropometric measurements and VO_2 max to evaluate the differences between male and female students, employing a t-test for statistical comparison. In addition, using Pearson's correlation analysis, the relationship between BMI, %BF, and VO_2 max of the students was examined at the University of Rajshahi's Department of Physical Education and Sports Science.

The findings of the current investigation showed that BMI was significantly higher in male students (23.20 ± 2.88) compared to the female students (19.41 ± 1.89), while %BF was significantly higher in female students (23.37 ± 4.73) than the male students (18.48 ± 5.42). These findings align with the study of Shu et al. 2012, who stated a significantly lower BMI but a higher %BF in females than the male participants (Shu Hua, Zheng Yan-song, IJ Chun-lin, Liu Min-yan, 2012). Similarly, a pediatric weight management study found that males had lower body fat percentage (%BF) but higher BMI percentiles than females at initial assessment (Quadri et al., 2025). In line with these findings, recent research involving elite handball athletes demonstrated that female players generally presented with higher %BF and lower BMI values than males (Cichy et al., 2020). These sex-based differences in body composition may be attributed to physiological variations, wherein males typically possess greater skeletal muscle mass, while females exhibit relatively higher adipose tissue distribution, particularly in the extremities (Schorr et al., 2018a).

There are no universal standards for classifying VO_2 max levels, however based on the Cooper Institute's percentile value, the mean VO_2 max (ml.kg-1.min-1) for male students was 37.50 ± 7.72, placing them in the "fair" group, while the mean VO_2 max (ml.kg-1.min-1) for female students was 35.94 ± 4.63, placing them in the "good" category (Pescatello, 2014), but the difference was not statistically significant. These findings supported by prior researches showing a VO_2 max value of 34.22±6.98 (mL/kg/min) in their participants (Liyana Hasnaa Mohd Daud & Azwani Mohd Shukri, 2022). However, some studies suggest that males tend to have significantly higher VO_2 max than females (Archana Khanna, 2018), which contrasts with our findings. This disparity might be explained by the fact that the study's participants were from a department where all students are physically active and regularly engage in various forms of exercise.

Furthermore, the current study demonstrated correlation between anthropometric parameters with VO_2 max to understand the relationship between BMI, %BF and VO_2 max. Results indicated that BMI is negatively correlated with VO_2 max for male students, while a very weak correlation was found in case of females. This discrepancy may be partially explained by sex-specific fat distribution patterns. Males are more likely to accumulate visceral fat, which is metabolically active and more detrimental to cardiovascular function, while females tend to store more subcutaneous fat, which may have a lesser impact on oxygen delivery and utilization (Palmer & Clegg, 2015; Schorr et al., 2018b). Such physiological differences could contribute to the varying strength of associations observed in this study. A recent study conducted by Vivek et al. (2021) identified a significant negative association ($r = -0.418$, $p < 0.01$) between BMI and VO_2 max in young male participants aged 18–25 years, indicating that a higher BMI is linked to lower aerobic fitness, as measured by VO_2 max (Vivek et al., 2021). In contrast, some studies have reported a weak association when comparing BMI and VO_2 max while suggesting a strong inverse association comparing %BF and VO_2 max (Mondal & Mishra, 2017). Another recent study demonstrated that, in comparison to BMI, body fat percentage (%BF) serves as a more accurate indicator of both obesity and cardiorespiratory fitness (Buttar et al., 2025). Similarly, in the present study, we observed both patterns, with %BF exhibiting a stronger negative correlation with VO2 max than BMI for both male and female students, suggesting %BF as a stronger predictor of cardiorespiratory fitness than BMI alone. These findings indicate that a higher body fat percentage is more responsible for reducing cardiorespiratory fitness level in students. A possible underlying mechanism is that excess body fat increases both metabolic and cardiovascular strain, thereby reducing the body's ability to efficiently deliver oxygen to working muscles during physical activity (Zhou, 2021; Chatterjee et al., 2005). Moreover, elevated %BF may impair exercise-induced lipolysis, limiting the availability of free fatty acids to skeletal muscles (Mittendorfer et al., 2004). This metabolic inflexibility constrains oxygen utilization, which in turn contributes to a reduction in VO_2 max (Mittendorfer et al., 2004; Frayn et al., 2007). Collectively, these factors help explain the observed inverse relationship between %BF and VO_2 max. In the same way, Minasian et al. 2014 stated that an elevated body fat percentage is linked to reduce cardiovascular fitness, which may lead to the development of chronic diseases (Minasian et al., 2014).

Multiple studies have demonstrated that aerobic exercise can be an effective method in reducing body fat and improving aerobic fitness level in terms of VO2 max (Nawawi, 2014)(Mith et al., 2013). According to current ACSM recommendations, healthy adults (18–65 years) should engage in at least 150 minutes per week of moderate-intensity aerobic exercise (or 75 minutes of vigorous exercise) combined with two or more resistance-training sessions weekly to optimize body composition and cardiorespiratory fitness (Medicine, 1998).

Additionally, BMI and %BF for both male and female students were found to be significantly positively correlated in this study, indicating that as BMI increases, %BF also tends to rise. This relationship likely reflects the contribution of adipose tissue to overall body mass, as increased fat accumulation elevates BMI despite its inability to distinguish between fat and lean mass. These findings are consistent with those of (Ilman et al., 2015), who reported a strong positive association between BMI and fat mass in university students, and (Nair, 2017), , who observed similar results in adult Indian males aged 35–45 years. Recent studies have also consistently demonstrated significant positive correlations between these two índices (Sun et al., 2023; Šlebodová et al., 2024).

Limitations

This study has several limitations that should be acknowledged. First, the relatively small sample size, drawn exclusively from one university department, may limit the generalizability of the findings to broader student populations or other institutions. Second, although the sample was randomly selected from the Physical Education department with equal sex representation, selection bias may still exist as the participants were drawn from a single academic unit. Third, although the *Queen's College Step Test* offers a practical and safe field method for estimating VO_2 max, its accuracy can vary based on participants' step rhythm adherence and pacing, potentially affecting consistency across individuals. A familiarization phase or stricter pace control could have improved standardization. Additionally, no control was applied for prior sleep quality or detailed dietary intake, which may influence both body composition and cardiorespiratory responses.

The study also relied on a cross-sectional design, which restricts the ability to infer causal relationships between body composition and cardiorespiratory fitness. Longitudinal or intervention-based research would be more suitable to explore cause-and-effect relationships.

Conclusions

The present study concludes that male students in the Department of Physical Education and Sports Science at Rajshahi University generally exhibit a 'fair' level of cardiorespiratory fitness, whereas female students demonstrate a 'good' level. A negative correlation was observed between both BMI and body fat percentage (%BF) with VO_2 max, indicating that elevated adiposity may impair aerobic capacity in this population. Rather than focusing solely on reducing fat, maintaining a healthy body composition appears essential for optimizing cardiorespiratory performance. Given their academic and professional orientation in Sports Science, these students may benefit from regular aerobic training to support optimal fitness. Future studies involving a larger and more diverse sample, along with additional physiological and behavioral variables, are recommended to strengthen and expand upon these findings.

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Ethical Standards

The ethical clearance for this study was obtained from the Institutional Animal, Medical Ethics, Biosafety and Biosecurity Committee (IAMEBBC) for Experimentation on Animal, Human, Microbes and Living Natural Sources, Institute of Biological Sciences, University of Rajshahi, Bangladesh (Memo no: 200/320(69)/IAMEBBC/IBSc; Dated: December 10, 2024). Written and informed consent of every participant was taken.

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