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Cardiorespiratory Fitness Level of College Students in terms of Abdominal Circumference, Body Mass Index, and Gender

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Abstract

Cardiorespiratory fitness refers to the integrated ability of the cardiovascular system with the respiratory system to provide oxygen to body tissues and is measured through VO_2max parameters. This variable is related to gender, abdominal circumference, and Body Mass Index (BMI). This cross-sectional study was analytical and involved 43 students as subjects selected by purposive sampling technique. Data were analysed descriptively and analytically using frequency distribution and chi-square test. The majority of the subjects were female (72%), with a mean abdominal circumference of 78.84 cm and included low risk (53%), a mean BMI of 24.88 and included normal (56%), and a mean VO_2 max of 11:02 including a very poor category (72%). Correlation tests of gender, abdominal circumference, and BMI with VO_2max showed p values of (p=0.000); (p=0.019) and (p=0.645) respectively, which means that there are differences in cardiorespiratory fitness between men and women; there is a statistically significant relationship between abdominal circumference and VO_2max level and there is no statistically significant relationship between BMI and VO_2max level. Exploration of the biological mechanisms behind gender disparities and the influence of body fat distribution on VO_2max needs to be studied longitudinally, in addition to testing the effectiveness of integrated interventions in improving the aerobic capacity of at-risk populations..

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INTRODUCTION

Physical fitness is performing daily physical labor without impairing biological, psychological, or social health (Solana et al., 2023). One component of physical fitness is cardiorespiratory fitness (VO_2max). Low cardiorespiratory fitness values are 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 students' physical fitness, showing different nutritional status (Malicevic et al., 2022).

Cardiorespiratory fitness is a key health indicator, particularly in preventing cardiovascular and metabolic diseases. The capacity of the cardiovascular and respiratory systems to distribute oxygen during physical activity significantly determines an individual's functional ability and risk of morbidity (Saynor et al., 2020). In university students, an optimal level of cardiorespiratory fitness supports academic performance and acts as a foundation for maintaining long-term health (Ivan et al., 2024; Hasan, 2024). As future medical personnel, health students have a moral responsibility to be role models in adopting a healthy lifestyle.

Gender differences significantly affect aerobic capacity. Males tend to have higher cardiorespiratory fitness levels than females (Benchelha, 2023). This is thought to be related to differences in body composition, such as greater muscle mass and a lower percentage of body fat in males, which physiologically favor the efficiency of the cardiovascular system. However, recent studies have also revealed that women with regular physical activity can achieve fitness levels equivalent to men despite different exercise patterns (Rohmah & Muhammad, 2021).

Abdominal circumference and BMI are also key indicators in assessing cardiorespiratory fitness. Large abdominal circumference, as a marker of central obesity, is often associated with increased risk of metabolic syndrome and decreased aerobic capacity . (Khanna et al., 2022). Abdominal circumference above normal tends to have lower VO2 max levels, indicating poor cardiorespiratory fitness. In addition, high BMI is often associated with decreased respiratory system efficiency and increased cardiac workload, ultimately affecting physical performance (Dwivedi et al., 2020). An increase in BMI is significantly correlated with a decrease in cardiorespiratory fitness.

Although many studies have examined the relationship between cardiorespiratory fitness and various factors, studies specifically focusing on health students are limited. Health students are a group that has in-depth knowledge about the importance of physical fitness and disease prevention. However, a sedentary lifestyle, academic pressure, and an unbalanced diet may challenge cardiorespiratory fitness.

More than 60% of most health students engage in more than 6 hours of sedentary activity daily, which may adversely affect their cardiorespiratory fitness (Paraschiv, 2024). High academic pressure may also affect health students' exercise habits and sleep patterns, ultimately affecting cardiorespiratory fitness (Etika et al., 2023).

Research conducted by Castro et al (2020) found that university students spend 7.29 hours/day in sedentary behavior (increasing to 9.82 hours/day based on accelerometers), much higher than the general young adult population. This suggests a correlation between high academic stress, low physical activity, and cardiorespiratory fitness.

This study aims to analyze the level of cardiorespiratory fitness in K3 students by reviewing the role of gender, abdominal circumference, and BMI; this study is expected to provide new insights into the determinants of cardiorespiratory fitness in the health student population. In addition, the results of this study can be the basis for developing intervention programs that are more effective in improving cardiovascular health and quality of life of health students.

METHODS

This study used a cross-sectional design to analyze the relationship between cardiorespiratory fitness with abdominal circumference, Body Mass Index (BMI), and gender. The study sample was 43 students selected using purposive sampling technique with inclusion criteria including (1) active students, (2) aged 18-25 years, (3) no history of cardiovascular disease, (4) not taking drugs that affect metabolism or physical performance, (5) willing to sign an informed consent and (6) following all research procedures. Meanwhile, the exclusion criteria included: (1) pregnant women, (2) had musculoskeletal injuries that hindered physical activity, (3) used mobility aids, (4) had acute conditions, (5) refused to complete any stage of the study, (6) had incomplete or invalid measurement data, and (7) had cognitive or mental impairments that affected the ability to follow instructions. This research was conducted in October 2024 at the Tri Lom-

ba Juang field, Semarang City. Data collection was conducted using two primary methods: (1) measurement of cardiorespiratory fitness using a 12-minute running test (Cooper test) that measures distance traveled as an indicator of aerobic capacity (VO_2max), (2) Measurement of abdominal circumference was performed using a measuring tape at the midpoint between the last rib and the pelvic bone when the subject exhaled. Height was measured with an upright stadiometer, while weight was measured using a calibrated digital scale. All measurements were taken by trained personnel with an accuracy of 0.1 cm/kg. BMI was calculated from body weight (kg) divided by the square of height (m^2). This protocol refers to WHO standards to ensure data accuracy. Data analysis in this study used descriptive and statistical analysis. Descriptive analysis was used to describe sample characteristics, including gender frequency distribution, mean±standard deviation of abdominal circumference (cm) and BMI (kg/m^2), and cardiorespiratory fitness category, which were presented in a frequency distribution table. Furthermore, statistical analysis using the chi-square test was conducted to test the relationship between categorical variables (gender, abdominal circumference category, and BMI category) and cardiorespiratory fitness level, with a significance level of $p<0.05$. Analyses were conducted using SPSS version 26 software, and results were presented in frequency distribution tables and cross-tabulations.

RESULTS AND DISCUSSION

The characteristics of the study subjects included gender, abdominal circumference, and body mass index, which are described in the following discussion:

Table 1 presents the characteristics of a sample population categorized by gender, abdominal circumference, and body mass index (BMI). In terms of gender, the sample consists of 12 males, accounting for 28% of the population, and 31 females, making up 72%. Regarding abdominal circumference, 15 individuals (35%) fall into the Very Low category, 23 individuals (53%) are classified as Low Risk, and 5 individuals (12%) are categorized as High Risk. For body mass index, 2 individuals (5%) are classified as Less, 24 individuals (56%) fall within the Normal range, 7 individuals (16%) are considered Overweight, and 10 individuals (23%) are categorized as Obesity.

Table 1. Characteristics of Research Subjects

	Characteristics	F	Frequency
Gender	Male	12	28%
	Female	31	72%
Abdominal Circumference	Very Low	15	35%
	Low Risk	23	53%
	High Risk	5	12%
Body Mass Index	Less	2	5%
	Normal	24	56%
	Overweight	7	16%
	Obesity	10	23%

Based on the data presented in **Table 2**, namely VO_2max level, it can be explained that most of the research sample has a cardiorespiratory fitness level (VO_2max), which is classified as very poor, 72% (31 students). Meanwhile, only 16% (7 students) had VO_2max levels in the Very Good category, and 9% (4 students) in the Poor category and the Excellent category, amounting to 2% (1 student). This distribution indicates that most of the sample had very low aerobic capacity, reflecting a suboptimal level of physical fitness. The high percentage of samples with Very Poor VO_2max indicates a significant health risk related to cardiorespiratory fitness in the sample studied.

Based on the measurement results presented in **Table 3** and **Table 4**, it can be concluded that there is a significant relationship between gender and VO_2max level, indicating a difference in cardiorespiratory fitness between men and women with the chi-square test results in Table 4 reinforcing this finding, with a Pearson Chi-Square value of 21.544 and a significance (p-value) of 0.000, a significance level of< 0.05.

Table 2. VO_2max Levels

VO2max Levels	F	%	Age	Abdominal Circumference	Height	Body Weight	IMT
Prima	7	16%	22 ± 0.93	82.29 ± 7.0	1.66 ± 0.04	68.57 ± 13.84	24.94 v 4.54
Excellent	1	2%	20 ± 0	107 ± 0	1.61 ± 0	99 ± 0	38.19 ± 0
Less	4	9%	21 ± 0	90.25 ± 10.78	1.7 ± 0.06	80.25 ± 17.02	27.72 ± 5.05
Very Less	31	72%	20.74 ± 0.4	75.68 ± 11.74	1.57 ±0.06	59.23 ± 13.78	24.02 ± 4.63

Table 3. Distribution of VO_2max Samples Based on Gender

Gender	VO2 max							
	Very Less		Less		Excellent		Prima	
	F	%	F	%	F	%	F	%
Male	3	6,97	3	6,97	0	0	6	13,95
Female	28	65,11	1	2,32	1	2,32	1	2,32

Table 4. Chi-Square Result Table

Test Item	Value	df	Asymp.Sig.
Pearson Chi-Square	21.544	3	.000

This discussion implies that gender factors may influence cardiorespiratory fitness capacity, with women tending to have lower fitness levels (Joyner, 2017). This finding aligns with previous studies that reported physiological differences between men and women, such as differences in body composition, muscle mass, and aerobic capacity (Epstein et al., 2015; Sandbakk et al., 2017). In studies examining gender differences, it is known that aerobic performance in men is higher than in women, with similar aerobic performance expressed as VO_2max / LBM (Wiecek et al., 2016). These findings align with this study, which explains that the percentage of men is greater than women in the context of VO_2max.

Laboratory studies reveal an interesting fact about sex differences in fatigue: Women are generally less intense than men, but they are more resistant to fatigue when performing isometric contractions, both sustained and intermittent, at the same relative intensity. These findings challenge common assumptions about physical endurance based on gender and open new insights into the unique physiological responses between men and women (Hunter, 2016). A study discussing differences in running speed between men and women showed that gender differences were visible in speed, where men outperformed women (Deaner & Lowen, 2016). Gender differences in speed are also seen in elite runners. A study that collected finish and split time data from 673 male and 549 female runners in nine Olympic and World Championship marathons revealed that female runners tend to be slower than males (Hanley, 2016).

Based on the data presented in **Table 5** and **Table 6**, the relationship between abdominal circumference and VO_2max level can be analyzed. The chi-square test results show a Pearson Chi-Square value of 15.182 and a significance (p-value) of 0.019. Since the p-value (0.019)< 0.05, it can be concluded that there is a statistically significant relationship between abdominal circumference and VO_2max level. This indicates that abdominal circumference, as an indicator of body fat distribution, affects the cardiorespiratory fitness capacity of individuals. Previous research has revealed a significant relationship between abdominal circumference and VO_2max capacity, an indicator of cardiorespiratory fitness (Ajeganova et al., 2021). The study found a significant correlation between waist circumference and VO_2max with a correlation coefficient of r = -0.61, suggesting that increased abdominal circumference is associated with decreased cardiorespiratory fitness in healthy young adults (Mondal et al., 2018). This finding aligns with a previous study conducted by (Hingorjo et al., 2017), which also discussed the significant relationship between abdominal circumference and VO2max, indicating that abdominal fat accumulation may decrease aerobic capacity. These two studies consistently confirmed that abdominal circumference is an important indicator affecting cardiorespiratory fitness, implying that managing abdominal circumference through lifestyle interventions may be an effective strategy to improve aerobic capacity and overall health. It was also found that there is a correlation between central obesity and cardiovascular fitness, where samples with higher central obesity were shown to have lower VO_2max values (Pojskic & Eslami, 2018). This finding is in line with the results of our analysis, where the group with High-risk abdominal circumference tended to have lower VO_2max levels.

Table 5. Distribution of VO_2max Samples Based on Abdominal Circumference

Vo2max	Abdominal Circumference					
	Very Low		Low Risk		High Risk	
	F	%	F	%	F	%
Very Less	11	25,58	18	41,86	2	4,65
Less	1	2,32	1	2,32	2	4,65
Excellent	0	0	0	0	1	2,32
Prima	3	6,97	4	9,30	0	0

Table 6. Chi-Square Result Table

Test Item	Value	df	Asymp.Sig.
Pearson Chi-Square	15.182	6	.019

In contrast, the group with "Very Low" and "Low" risk abdominal circumference showed a higher proportion in the better VO_2max category. Studies addressing the relationship of combined exercise with abdominal circumference explain that a modified physical exercise program can

effectively reduce abdominal circumference and increase VO_2max (Firmansyah et al., 2019, Mora-Rodriguez et al., 2020). Decreasing abdominal circumference significantly increases aerobic capacity, confirming weight management's importance for cardiorespiratory fitness. Related studies suggest that low levels of cardiorespiratory fitness are associated with a higher risk of developing abdominal fat and obesity (Ortega et al., 2019). Overall, the findings of previous studies reinforce the importance of abdominal circumference as a key indicator in fitness assessment and the development of health intervention programs while emphasizing the need for a holistic approach that considers genetic factors, lifestyle, and exercise programs in improving cardiorespiratory fitness.

Table 7. Distribution of VO_2max Samples Based on BMI

VO2 max	BMI							
	Less		Normal		Overweight		Obesity	
	F	%	F	%	F	%	F	%
Very Less	2	4,65	18	41,86	6	13,95	5	11,62
Less	0	0	2	4,65	0	0	2	4,65
Excellent	0	0	0	0	0	0	1	2,32
Prima	0	0	4	9,30	1	2,32	2	4,65

Table 8. Chi-Square Result Table

Item Test	Value	df	Asymp.Sig.
Pearson Chi-Square	6.923	9	.645

Based on the data presented in **Table 7** and **Table 8**, the relationship between Body Mass Index (BMI) and VO_2max level can be analyzed. The chi-square test results show a Pearson ChiSquare value of 6.923 with a degree of freedom (df) of 9 and a significance (p-value) of 0.645. Since the p-value (0.645)> 0.05, it can be concluded that there is no statistically significant relationship between BMI and VO_2max level. This indicates that the BMI category did not significantly influence the distribution of cardiorespiratory fitness levels in the observed sample.

A study involving 8470 healthy adults found no significant association between Body Mass Index (BMI) and cardiorespiratory fitness, measured as VO_2max when controlling for age, height, and gender. This suggests that BMI is not a strong predictor of VO_2max in the general population (Takken et al., 2022). This finding confirms that BMI, as an indicator of relative body weight, may not be sufficient to describe an individual's cardiorespiratory fitness capacity. Other factors such as body composition, fat distribution, and physical activity level may be more important in determining VO_2max (Alvero-Cruz et al., 2020, Randell et al., 2017). In a study conducted by (Mondal & Mishra, 2017), BMI showed a weak but statistically significant negative correlation with VO_2max ($r = -0.3232$, $p = 0.0171$), indicating that an increase in BMI tends to be followed by a decrease in VO_2max, although this relationship is not strong. This finding is interesting because although there was a significant relationship, the strength of the correlation was much weaker compared to the strong negative correlation between body fat percentage and VO_2max ($r = -0.7505$, $p < 0.001$). This confirms that body fat percentage may be a stronger and more relevant predictor of cardiorespiratory fitness than BMI, which only provides a limited picture of body composition.

CONCLUSION

Based on the descriptions obtained in this study, the majority of respondents (72%) had VO2max levels in the "Very Poor" category. There was a clear difference between men and women, with men having better VO_2max capacity (p-value <0.001). Waist circumference was also found to influence VO_2max (p-value = 0.019), with those having a high-risk waist circumference tending to have lower VO_2max. However, body weight measured via BMI did not show an influence on VO_2max (p-value = 0.645). These findings emphasize the importance of a holistic approach in fitness assessment by considering gender, body fat distribution, physical activity factors, and the need for specific interventions to improve aerobic capacity. Future research is recommended to explore the biological mechanisms behind gender disparities and the influence of body fat distribution on VO_2max through longitudinal studies and test the effectiveness of integrated interventions in improving the aerobic capacity of at-risk populations.

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