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The Relationship of Body Mass Index and Waist Circumference with Cardiorespiracy Fitness in Medical Students of UIN Alauddin Makassar

Adellia Tuffahati Dhiya Ulhaq[1*], Andi Tihardimanto Kaharuddin[2], Abd.Rahman[3], Jelita Inayah Sari[4], Arifuddin Ahmad[5]

[1,2,3,4]Department of Medical Education, Faculty of Medicine and Health Science, Alauddin State Islamic University of Makassar
[5]Department of Hadith Studies, Faculty of Ushuluddin and Philosophy, Alauddin State Islamic University of Makassar

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Abstract

Cardiorespiratory fitness refers to the ability of the heart, lungs, and blood vessels to function optimally, providing adequate oxygen supply to the muscles during physical activity. This research aims to determine the relationship between body mass index and waist circumference with cardiorespiratory fitness in medical students at UIN Alauddin Makassar. The research design is an observational analytic approach with a cross-sectional design. The population in this study consists of all preclinical medical students at UIN Alauddin Makassar. The sampling technique used is purposive sampling, with a minimum sample size of 140. Cardiorespiratory fitness is the dependent variable, while body mass index (BMI) and waist circumference are the independent variables. Data were analyzed using univariate and bivariate tests with SPSS software. The results of the study show a significant relationship between BMI and cardiorespiratory fitness (p-value < 0.05), indicating a moderate negative correlation (r = -0.418). There is also a significant relationship between waist circumference and cardiorespiratory fitness (p-value < 0.05), indicating a strong negative correlation (r = -0.650). This study concludes that there is a significant relationship between BMI and waist circumference with cardiorespiratory fitness in medical students at UIN Alauddin Makassar.

Keywords: Body Mass Index, Waist Circumference, Cardiorespiratory Fitness

Abstrak

Kebugaran kardiorespirasi merupakan kemampuan sistem jantung, paru-paru, serta pembuluh darah untuk bekerja secara optimal sehingga mampu memberikan suplai oksigen yang memadai pada otot-otot yang bekerja. Tujuan penelitian ini untuk mengetahui hubungan indeks massa tubuh dan lingkar pinggang dengan kebugaran kardiorespirasi pada mahasiswa kedokteran UIN Alauddin Makassar. Desain penelitian adalah analitik observasional dengan pendekatan *cross sectional*. Populasi pada penelitian ini adalah semua mahasiswa preklinik kedokteran UIN Alauddin Makassar. Teknik pengambilan sampel yang digunakan adalah purposive sampling dengan minimal sampel sebanyak 140 sampel. Kebugaran kardiorespirasi sebagai variabel dependen dan dinilai menggunakan *Harvard step test*. Indeks massa tubuh dan lingkar pinggang sebagai variabel independen. Data dianalisis menggunakan uji univariat dan bivariat menggunakan aplikasi SPSS. Hasil penelitian menunjukkan bahwa terdapat hubungan yang bermakna antara indeks massa tubuh dengan kebugaran kardiorespirasi (p-value <0,05) serta memiliki tingkat korelasi sedang dengan arah korelasi negatif (r=-0.418). Terdapat hubungan yang bermakna antara lingkar pinggang dengan kebugaran kardiorespirasi (p-value <0,05) serta memiliki tingkat korelasi kuat dengan arah korelasi negatif (r=-0.650). Penelitian ini dapat disimpulkan terdapat hubungan yang bermakna antara indeks massa tubuh dan lingkar pinggang dengan kebugaran kardiorespirasi pada mahasiswa kedokteran UIN Alauddin Makassar.

Kata kunci: Indeks Massa Tubuh, Lingkar Pinggang, Kebugaran Kardiorespirasi

Introduction

The health of students is a crucial aspect that not only affects academic performance but also reflects the overall quality of life. In this context, cardiorespiratory fitness becomes an important indicator that reflects heart-lung health and endurance, playing a crucial role in determining overall productivity levels. According to the 2018 Riset Kesehatan Dasar (Riskesdas) results, the physical fitness level of the Indonesian population remains relatively low, as manifested in the prevalence of insufficient physical activity, which reaches 33.5%. In South Sulawesi, the prevalence of insufficient physical activity is 33.4%. In Makassar City, the prevalence of people with insufficient physical activity remains high, at 31.92%.[1–3]

Cardiorespiratory fitness reflects the ability of the cardiovascular and respiratory systems to efficiently supply oxygen to the body during physical activity. Maximal oxygen volume can be used as a quantitative measure to assess the level of cardiorespiratory fitness. Maximal oxygen volume represents the maximum amount of oxygen that the body can take in and utilize during physical activity. The higher an individual's maximal oxygen volume, the higher their fitness level. The Harvard step test is one of the tests used to assess cardiorespiratory fitness by measuring an individual's aerobic capacity. The Harvard Step Test is used to evaluate the cardiorespiratory fitness index by stepping up and down on an 18-inch bench for 3 minutes in rhythm with a metronome set at 120 beats per minute (bpm). The test categorizes physical fitness levels into poor, average, and good. The speed at which the heart rate returns to normal is directly proportional to the individual's physical fitness level.[4]

One factor that can impact cardiorespiratory fitness is nutritional status. Adequate nutrition has a positive impact on physical fitness, while inadequate nutrition, whether due to deficiency or excess, can have a negative effect on physical fitness. Nutritional status assessment can be conducted using anthropometric approaches. Anthropometry is a method used to evaluate the size, proportions, and composition of the human body. The distribution of body fat consists of subcutaneous fat (fat beneath the skin) and visceral fat (fat in the abdominal area). The amount of subcutaneous and visceral fat can be estimated by measuring body mass index (BMI) and waist circumference.[5,6]

In terms of nutritional status, Indonesia is currently facing a dual challenge in nutrition, known as the double burden of malnutrition. In this context, issues of undernutrition, such as malnutrition, stunting, and underweight, coexist with problems of overnutrition, such as obesity or overweight, which are caused by unhealthy eating habits, lifestyles, and physical inactivity. This situation has become one of the factors contributing to the increasing cases of degenerative diseases in Indonesia. Degenerative diseases, which fall under the category of non-communicable diseases, are defined as conditions arising from the decline in organ function, such as heart disease, hypertension, diabetes, and similar conditions. Although the majority of degenerative disease cases occur in individuals over the age of 30, these diseases are now increasingly affecting individuals of working age. Nutritional imbalances can lead to serious consequences, especially when there is a lack of awareness regarding the dangers of degenerative diseases. Without early awareness of the risks of degenerative diseases, individuals become vulnerable to various conditions that may reduce life expectancy. Therefore, routine health

screenings from an early age are a crucial preventive measure to avoid the adverse effects of degenerative diseases in the future.[7,8,9]

The description above indicates that there is currently an issue affecting the decline in cardiorespiratory fitness, which is linked to the increase in body mass index (BMI) and waist circumference. The researcher is interested in conducting a study to investigate the "Relationship Between Body Mass Index and Waist Circumference with Cardiorespiratory Fitness in Medical Students at UIN Alauddin Makassar".

Methods

This study used an analytical observational research design with a cross-sectional approach. The research was conducted at Campus 1 of UIN Alauddin Makassar, from December 18 to 22, 2023. The ethical code for this study is No. E.024/KEPK/FKIK/XII/2023, issued by the Faculty of Medicine and Health Science, Alauddin State Islamic University of Makassar. The population in this study consisted of all preclinical medical students at UIN Alauddin Makassar. The exclusion criteria in this study include individuals with cardiovascular and pulmonary diseases, those with musculoskeletal disorders, and active smokers. Based on calculations using the Slovin formula, the minimum required sample size was 140. The samples in this study were selected using purposive sampling. The data used in this research were primary data, collected through direct measurements on the research samples. The types of cardiorespiratory fitness measurements used in this study are body mass index (BMI) and waist circumference. The research instruments used included a microtoise, scale, measuring tape, Harvard step bench, stopwatch, and metronome.

Measurement of cardiorespiratory fitness using the Harvard Step Test. The Cardiorespiratory Fitness Index (CFI) was calculated using the following formula: CFI = (Duration of stepping in seconds × 100) / (5.5 × pulse rate during 30 seconds). Cardiorespiratory fitness was classified into three categories based on the index score: poor (less than 50), average (ranging from 50 to 80), and high (greater than 80). Waist circumference was measured by placing a measuring tape around the abdomen at the midpoint between the iliac crest and the lower margin of the costal arch. The interpretation was classified as high risk for women with a result of ≥80 cm and for men with a result of ≥90 cm, while low risk was defined as a result of <80 cm for women and <90 cm for men. Body Mass Index (BMI) was determined using the formula weight (kg) divided by height squared (m^2). Based on the classification, individuals were categorized as underweight if the BMI was <17.0 or ranged from 17.0 to 18.4 kg/m^2, normal if the BMI ranged from 18.5 to 25.0 kg/m^2, and overweight if the BMI ranged from 25.1 to 27.0 or exceeded 27.0 kg/m^2. Data analysis in this study involved both univariate and bivariate analyses, with the data processed using the Statistical Package for the Social Sciences (SPSS Statistics, version 30.0).

Result

Table 1 illustrates the frequency distribution of various sample characteristics, including gender, class group, body mass index, waist circumference, and cardiorespiratory fitness. The study included a total of 140 samples that met the inclusion criteria.

Table 1. Frequency distribution of sample characteristics

Category	Frequency	Presentation %
Gender		
Male	32	22.8
Female	108	77.2
Class Group		
2020	41	29.4
2021	18	12.8
2022	32	22.8
2023	49	35.0
Body Mass Index		
Thin	25	17.9
Normal	73	52.1
Fat	42	30.0
Waist Circumference		
Low Risk	97	69.3
High Risk	43	30.7
Cardiorespiratory Fitness		
Poor	64	45.7
Average	19	13.6
High	57	40.7
Total	140	100.0

Table 2 presents the results of the analysis assessing the relationship between body mass index (BMI) and cardiorespiratory fitness using the Chi-square statistical test, which yields a p-value of 0.000, indicating a significance level below 5% (0.05). This suggests a significant relationship between BMI and cardiorespiratory fitness. Based on the Spearman's Rho correlation test, the correlation coefficient (r = -0.418) indicates a moderate negative correlation between BMI and cardiorespiratory fitness. This means that the higher the BMI, the lower the level of cardiorespiratory fitness.

Table 2. The relationship between body mass index and cardiorespiratory fitness

Cardiorespiratory Fitness	Body Mass Index			Total	*p-value*	r
	Thin (n(%))	Normal (n(%))	Fat (n(%))			
Poor	12 (8.5%)	13 (9.3%)	39 (27.9%)	64 (45.7%)	0.000	-0.418
Average	5 (3.6%)	11 (7.9%)	3 (2.1%)	19 (13.6%)		
High	8 (5.7%)	49 (35.0%)	0 (0.0%)	57 (40.7%)		
Total	25 (17.8%)	73 (52.2%)	42 (30%)	140 (100.0%)		

Table 3 presents the results of the analysis assessing the relationship between waist circumference and cardiorespiratory fitness using the Chi-square statistical test, which yields a p-value of 0.000, indicating a significance level below 5% (0.05). This suggests a significant relationship between waist circumference and cardiorespiratory fitness. Based on the Spearman's Rho correlation test, the correlation coefficient (r = -0.650) indicates a strong negative correlation between waist circumference and cardiorespiratory fitness. This means that the larger the waist circumference, the lower the level of cardiorespiratory fitness.

Table 3. The relationship between waist circumference and cardiorespiratory fitness

Cardiorespiratory Fitness	Waist Circumference		Total (n(%))	*p-value*	r
	High Risk (n(%))	Low Risk (n(%))			
Poor	41 (29.3%)	23 (16.4%)	64 (45.7%)	0.000	-0.650
Average	2 (1.4%)	17 (12.2%)	19 (13.6%)		
High	0 (0.0%)	57 (40.7%)	57 (40.7%)		
Total	43 (30.7%)	97 (69.3%)	140 (100.0%)		

Discussion

The results of the study reveal a significant correlation between body mass index (BMI) and cardiorespiratory fitness in medical students at UIN Alauddin Makassar, as determined by the Chi-square test, with a p-value of 0.000. This finding is consistent with the research conducted by Nadya Gantarialdha (2021), which found a significant relationship between BMI and cardiorespiratory fitness, measured through maximal oxygen volume. In this case, the relationship between BMI and maximal oxygen volume is inverse, indicating that the lower the BMI, the higher the maximal oxygen volume. Conversely, the higher the BMI, the lower the maximal oxygen volume.[10]

This finding is also in line with the research conducted by Salma Khairunnisa et al. (2023), which reported a correlation coefficient of -0.812 and a significance value of 0.001 using the Spearman correlation test. This study confirms a significant correlation between BMI and maximal oxygen uptake.[11]

The study noted that the majority of medical students exhibit low levels of physical activity due to high levels of sedentary behavior. This condition occurs because medical students tend to allocate most of their time to studying or completing academic tasks. Students who spend a significant amount of time engaging in sedentary activities are more likely to have an excessive body mass index, which in turn leads to a lower maximal oxygen volume.[12]

Body mass index (BMI) can be influenced by various factors, including an individual's eating habits and lifestyle. The consumption of unhealthy food can impact the body's nutritional intake. Unhealthy eating habits can lead to an imbalanced nutrient intake, and if not balanced with adequate energy expenditure, can increase the risk of a higher BMI. Similarly, a sedentary lifestyle or lack of physical activity can also contribute to changes in a person's BMI.[13,14]

he accumulation of excessive body fat can lead to an increase in body mass, and according to Newton's Second Law of Motion, this will result in a decrease in the body's acceleration when it is in motion. Therefore, being overweight typically results in limitations in an individual's flexibility during various activities or tasks.[15]

The accumulation of fat in the body can become an obstacle and cause disturbances in heart function. These functional disturbances can lead to a decrease in cardiac output, reduce the amount of blood pumped, and cause a decrease in the oxygen supply to the muscles. As a result, the musculoskeletal system is unable to receive an optimal oxygen supply during physical activity. This condition leads to a depletion of oxygen stores, which can hinder the aerobic respiration process in muscles. Under these conditions, muscles are forced to shift from aerobic respiration to anaerobic respiration, a process that does not involve oxygen and is known as

anaerobic glycolysis. Anaerobic glycolysis is effective in providing Adenosine Triphosphate (ATP) quickly without the involvement of oxygen. However, the negative consequence of anaerobic glycolysis is the production of lactic acid. The accumulation of lactic acid can be detrimental, as it has the potential to cause significant muscle fatigue. Therefore, this condition can affect physical performance and limit muscle endurance during physical activity.[10,16,17]

Furthermore, the study's results reveal a significant correlation between waist circumference and cardiorespiratory fitness in medical students at UIN Alauddin Makassar, as determined by the Chi-square test, with a p-value of 0.000. This finding is consistent with the research conducted by Ni Made Rikawiantari et al. (2022), which used the Spearman's rho correlation test and showed a p-value of 0.000 and a correlation coefficient of r = -0.526. These results indicate a significant relationship between waist circumference and maximal oxygen volume, with a negative correlation, suggesting an inverse relationship between the two variables. In other words, the larger the waist circumference, the lower the maximal oxygen consumption.[15]

This study presents findings that differ from those of Ni Komang Ayu Mega Juliyanty et al. (2022), which found no significant relationship between BMI and cardiorespiratory endurance. The analysis using Fisher's Exact Test yielded a p-value of 1.000. Similar findings were also reported in another study by Feny Safitri et al. (2020), which showed no significant relationship between cardiorespiratory fitness and BMI among students at SDN 001 Merdeka, Bandung. The Spearman correlation analysis yielded a p-value of 0.058. These studies are not in line with the present research, possibly because cardiorespiratory fitness is influenced by several factors, one of which is physical activity. Physical activity plays a crucial role in enhancing cardiorespiratory endurance, as it can increase maximal oxygen uptake.[18,19]

Waist circumference exceeding the normal limit is often associated with an increased risk of cardiovascular diseases and metabolic health disorders. As an indicator of abdominal fat, waist circumference can provide an early indication of potential risks related to central obesity. Fat deposits can also occur in the abdomen and chest wall, leading to excessive stretching of the chest wall. This can result in a decrease in chest wall compliance, thus limiting the movement of the rib bones or reducing thoracic mobility. Additionally, the respiratory muscles must work harder to generate high pressure in the pleural cavity, allowing air to flow in during inspiration. This increased effort by the respiratory muscles raises oxygen consumption and production, leading to increased ventilation. Fat accumulation in the body can limit lung expansion during inspiration and reduce the caliber of peripheral airways, causing them to narrow significantly and triggering the development of hypoxemia.[20–22]

In this study, the researcher identified several limitations due to the research constraints. One of the limitations was the difficulty in matching class schedules with the research sample, which resulted in a considerable amount of time being spent on the data collection process.

Conclusion

Based on the findings, there is a significant relationship between body mass index and waist circumference with cardiorespiratory fitness among medical students at UIN Alauddin Makassar. It is recommended that students and the general public undergo regular body

composition screenings (BMI and waist circumference), engage in consistent aerobic physical activities, and adopt a balanced, nutritious diet to maintain optimal cardiorespiratory fitness.

For future researchers, it is hoped that further development of this study will include additional variables for examination and the use of different fitness test methods to observe variations in results across various methods. All of these efforts aim to enhance the research findings in a broader context.

Conflict of Interest

In this study, the authors declare that they have no affiliations or involvement with any organization or entity with any financial interests (such as honoraria, educational grants, memberships, employment, stock ownership, or other equity interests), or non-financial interests such as personal or professional relationships, affiliations, knowledge, or beliefs related to the subject matter or topics discussed in this manuscript.

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