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Factors Affecting Cardiorespiratory Fitness among Medical Students: A Cross-Sectional Study

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Abstract **Introduction:** Maintaining physical health among medical students is vital, as it can significantly impact their cardiorespiratory fitness. The sedentary lifestyle of medical students can lead to concerning health problems in the future. **Purpose:** This study explored multiple aspects of medical students' well-being, including cardiorespiratory durability, physical fitness, blood pressure, chronotype, and body composition. We aimed to provide a holistic health profile for medical students. **Methods:** This cross-sectional analysis involved 142 medical students who met specific criteria. Data collection methods included questionnaires, various physical measurements, and Harvard step fitness tests. Statistical analyses of Spearman's rank, Mann-Whitney U, and Pearson correlation tests were used to assess the relationships between various health parameters. **Results:** Majority of study participants (80.3%) exhibit below normal cardiorespiratory fitness. Gender (p=0.009), physical activity (p=0.005), muscle mass (p=0.000), systolic (p=0.000) and diastolic blood pressure (p=0.001) exhibited positive correlations with cardiorespiratory fitness. Visceral fat (p=0.022) and body mass index (p=0.000) showed negative correlations with cardiorespiratory fitness. However, lung vital capacity showed no significant relationship (p=0.811). Sleep quality (p=0.995) and chronotype (p=0,100) also displayed no significant relationship. **Conclusions:** This study found complex relationships among gender, physical activity, body mass index, muscle mass, visceral fat, sleep quality, blood pressure, lung vital capacity, and chronotype in medical students. Enhancing physical activity, maintaining a healthy body mass index, and improving sleep quality are critical for students' overall well-being.

Keywords Medical Students, Physical Fitness, Cardiorespiratory Fitness, Body Composition

1. Introduction

In recent years, the sedentary lifestyle of students has led to a concerning increase in incidents of disease related to cardiovascular and respiratory system, particularly among those who spend prolonged hours sitting [1]. Research done previously in 2017 showed a direct link between elevated body mass index (BMI) and a sedentary lifestyle with high blood pressure among medical students. Elevated BMI correlated with higher blood pressure, underscoring the impact of sedentary habits on hypertension [2].

Hypertension, characterized by high blood pressure, is influenced by various risk factors, including age, genetics, physical inactivity, stress, unhealthy diets, obesity, smoking, and alcohol consumption [3]. A sedentary lifestyle exacerbates these risk factors, resulting in increased blood pressure [4]. The consequences of sedentary living extend to obesity and age-related increases in blood pressure, posing additional health risks. As sedentary habits persist, the risk of hypertension rises due to autonomic nervous system imbalances, potentially leading to enduring autonomic dysfunction [5]. Beyond affecting blood pressure, sedentary lifestyles also impact lung vital capacity, a crucial measure of respiratory function and muscle performance during breathing. Reduced lung vital capacity corresponds to diminished physical fitness [6]. Therefore, reintroducing physical activity into one's routine can help normalize autonomic tone, ensuring stable and optimal cardio-respiratory function [1]. For this reason, blood pressure and lung function can serve as essential indicators of overall fitness [4,5].

In medical education, students also face unique challenges characterized by rigorous academic demands and heightened stress levels, making them susceptible to sleep disturbances, poor sleep quality, and unhealthy sleep habits. These issues have repercussions for physical and psychological health [2].

Sleep quality significantly influences physical and mental well-being, with poor sleep quality leading to fatigue, reduced daily functioning, compromised immunity, unstable vital signs, stress, depression, and anxiety [7]. Understanding how sleep quality, patterns, and chronotypes relate to students' physical fitness and well-being is essential. Sleep quality is influenced by circadian rhythms, governing physiological and behavioral functions across a 24-hour cycle. Chronotype categorizes individuals as morning (early chronotypes), evening (late chronotypes), or intermediate types, and is linked to the timing of physical activity and overall health [8]. Recent research links chronotype to body composition, with evening types more likely to have higher BMIs due to less healthy lifestyle choices, reduced physical activity, unhealthy eating habits (especially at night), and a greater tendency toward alcohol and tobacco consumption [9]. Moreover, evening types experience a more significant increase in BMI with age than morning types. Studies also found that evening types exhibit higher waist circumferences, triglyceride levels, and visceral fat, particularly among women. These associations stem from lifestyle factors, metabolic changes, and lower melatonin hormone levels in evening types [10].

In summary, our study aims to explore various aspects of medical students' health and fitness, delving into the intricate relationships between sedentary lifestyles, physical fitness, blood pressure, lung function, sleep quality, chronotype, BMI, and body composition. Through rigorous research, we seek to contribute valuable insights to medical education and public health, ultimately enhancing the well-being of all individuals within the medical faculty.

2. Materials and Methods

2.1. Research Design

In our study, we used a cross-sectional observational analytical design in our quantitative investigation. This study design made it possible to gather data at a certain moment in time, giving an overview of several factors within a given population.

2.2. Setting and Samples

The research was conducted between November 2022 and May 2023 within the premises of Universitas Muhammadiyah Semarang, with specific locations including the Faculty of Medicine and Gedung Serba Guna. The target population for our study was the year 2022 students from the Faculty of Medicine at Universitas Muhammadiyah Semarang.

A total sampling technique was employed in our study, resulting in sample sizes of 142 students. The inclusion criteria encompassed active student status, between age of 19-21 years old, willingness to cooperate by signing an informed consent form, and additional criteria such as the absence of cardiovascular and chronic pulmonary diseases, no lower limb injuries, and no active smoking history.

2.3. Measurement and Outcome Measures

Participants eligible for the study were initially required to fill out a form of personal information such as their date of birth, age, and gender. Subsequently, a series of measurements were conducted to assess various health parameters. Body mass index (BMI) according to Asia Pacific region and body composition (including total fat, visceral fat, and muscle mass) were measured through Omron HBF-375 Karada Scan Bioelectrical Impedance Analysis (BIA) which will be adjusted according to parameters for Indonesians according to Hastuti *et al.* [11]. In addition to these assessments, clinical measurements included systolic and diastolic blood pressure obtained using an OMRON HEM-8712 digital sphygmomanometer, vital lung capacity measured via Contec Sp100 Digital Spirometer, and a cardiorespiratory fitness index determined using the short form Harvard step test, calculated as (100*duration in seconds) divided by (5.5*pulse count between 1 to 1.5 minutes). We set the cutoff scores for abnormal cardiorespiratory fitness to be equal to or below 54 which correspond to the "poor/below average" category on the Harvard step test [12].

Furthermore, participants were also evaluated through self-report questionnaires. These questionnaires encompassed the Pittsburgh Sleep Quality Index (PSQI), the International Physical Activity Questionnaires (IPAQ) short form, and the Morningness-Eveningness Questionnaire (MEQ). The PSQI assesses sleep quality over one month interval. Its global score ranges from 0 to 21, where a score of 5 or more denotes poor quality of sleep. The IPAQ short form consists of 8 questions that assess physical activity levels over the past week. It investigates the frequency in days and duration in minutes of walking, moderate, and vigorous activities. Utilizing the following formula, weekly total physical activity is determined as the metabolic equivalent of task minutes per week (MET-min/week) based on the obtained data: (3.3*min*days) + 4*min*days) + (8*min*days) for walking, moderate, and vigorous activities respectively. After that, participants are divided into three activity categories: low (<600 MET-min/week), moderate (600-1500 MET-min/week), and high (>1500 MET-min/week) [13]. Last but not least, the MEQ is composed of five components: rising time, peak time, retiring time, morning freshness, and chronotype self-evaluation. Each component has a score, and the total score, which runs from 16 to 86, divides people into three categories: morning types (59-86), middle types (42-58), and evening types (16-41) [14].

2.4. Data Analysis

Our study employed univariate and bivariate statistical analysis techniques. The characteristics of study participants were described using univariate descriptive analysis, presented as number and percentages. Bivariate analysis of numeric data was performed to explore relationships between variables, including Pearson correlation and Spearman rank correlation test, depending on the nature of the variables and their distributions. The data's normality was evaluated using the Kolmogorov-Smirnov test. For normally distributed data, Pearson correlation was used, and for non-normally distributed data, Spearman correlation was used, with a significance level (p-value) of less than 0.05 indicated as statistically significant. The data analysis used IBM SPSS Statistics version 25.

2.5. Ethical Considerations

Informed consent was obtained from the student participants. Additionally, ethical considerations were approved by the Health Research Ethics Committee, as indicated by the reference number: *Surat Keputusan Layak Etik Fakultas Kedokteran* UNIMUS No. 116/EC/KEPK-FK/UNIMUS/2022.

3. Results

As shown in Table 1, Majority of study participants (80.3%) exhibit below normal cardiorespiratory fitness. Male participants had a higher percentage of normal cardiorespiratory fitness participants (24.1%) compared to their female counterparts (8.0%). Our data also indicate that 40% of participants in the high physical activity group had normal cardiorespiratory fitness. Surprisingly, the group with the highest percentage of normal cardiorespiratory fitness was found among participants with hypertensive blood pressure (20%). The ideal body mass index (BMI) was within the normal BMI range, which had the largest percentage (22.2%) of participants in the normal cardiorespiratory fitness category. Additionally, the high muscle mass category had the largest percentage of participants with normal cardiorespiratory fitness (25.0%). Participants with normal visceral fat levels had the highest percentage of normal cardiorespiratory fitness (13.9%). Our study also found that while the majority of participants had poor sleep quality, those with good sleep quality had the highest percentage (25.0%) of normal cardiorespiratory fitness. Lastly, most participants with an evening chronotype were in the normal category of cardiorespiratory fitness (26.7%).

Table 1. Study participants' characteristics

Variable	Cardiovascular Fitness		Total
	Below Normal	Normal	
Gender			
Male	44 (75.9%)	14 (24.1%)	58
Female	70 (83.3%)	14 (16.7%)	84
Physical Activity			
Low (<600 MET min/week)	71 (91%)	7 (9%)	78
Medium (600 – 1500 MET min/week)	40 (74.1%)	14 (25.9%)	54
High (>1500 MET min/week)	6 (60.0%)	4 (40.0%)	10
Blood Pressure			
Normal (SBP <120 or DBP <80 mmHg)	93 (90.3%)	10 (9.7%)	103
Prehypertensive (SBP 120-139 or DBP 80-89 mmHg)	16 (84.2%)	3 (15.8%)	19
Hypertensive (SBP ≥140 or DBP ≥90 mmHg)	16 (80.0%)	4 (20.0%)	20
Body Mass Index			
Less (< 18.5 kg/m^2)	15 (88.2%)	2 (11.8%)	17
Normal (18,5-22,9 kg/m^2)	42 (77.8%)	12 (22.2%)	54
Overweight (23-24.9 kg/m^2)	24 (85.7%)	4 (14.3%)	28
Obesity I (25-29.9 kg/m^2)	31 (96.9%)	1 (3.1%)	32
Obesity II (≥ 30 kg/m^2)	11 (100.0%)	0 (0%)	11
Muscle Mass			
Low (male: <32.8%, female: <25.8%)	58 (95.1%)	3 (4.9%)	61
Normal (male: 32.9-35.7%, female: 25.9-27.9%)	41 (87.2%)	6 (12.8%)	47
High (male: 35.8-37.3%, female: 28-29%)	12 (75.0%)	4 (25.0%)	16
Very High (male: >37.3%, female: >29%)	14 (77.8%)	4 (22.2%)	18
Visceral fat			
Normal (1-9%)	105 (86.1%)	17 (13.9%)	121
High (10-14%)	15 (100.0%)	0 (0%)	17
Very High (>14%)	5 (100.0%)	0 (0%)	4
Sleep Quality			
Good (PSQI Score <4)	6 (75.0%)	2 (25.0%)	8
Bad (PSQI Score ≥5)	119 (88.8%)	15 (11.2%)	134
Chronotype	11 (73.3%)	4 (26.7%)	15
Evening Type (MEQ score 16-41)	55 (93.2%)	4 (6.8%)	59
Intermediate Type (MEQ score 42-58)	59 (86.8%)	9 (13.2%)	68
Morning Type (MEQ score 59-86)			
Total	114 (80.3%)	28 (19.7%)	142

In this study we used data in numeric to determine correlation coefficient and its direction (negative or positive). In Kolmogorov Smirnov test, we found variables that were non-normally distributed. Therefore, the non-parametric test of Spearman correlation was employed on these variables. The results of bivariate analysis can be seen on Table 2.

Table 2. Analysis of factors associated with Cardiorespiratory Fitness

Variables	Correlation Coefficient	p value
Body Mass Index (BMI)	-0.320	0.000*
Systolic Blood Pressure	0.367	0.000*
Diastolic Blood Pressure	0.314	0.001*
Subcutaneous Fat	0.026	0.770
Gender	0,237	0.009**
Physical Activity	0.263	0.005**
Total Body Fat	0.013	0.885
Visceral Fat	-0.193	0.022**
Muscle Mass	0.399	0,000**
Sleep Quality	-0.001	0.995
Lung Vital Capacity (VC)	0.050	0.811
Chronotype	-0.144	0.100

*p<0.05; significantly correlated; Pearson correlation

**p<0.05; significantly correlated; Spearman correlation

As shown in Table 2, for normally distributed data using Pearson correlation, our study identified a moderate inverse relationship between Body Mass Index (BMI) and cardiorespiratory fitness (-0.320, p=0.000). Cardiorespiratory fitness and Systolic blood pressure (0.367, p=0.000) were found to be moderately positively correlated, and the same goes to diastolic blood pressure (0.314, p=0.001). Subcutaneous fat showed no significant correlation with cardiorespiratory fitness (0.026, p=0.770). For non-normally distributed data, gender exhibited a positive correlation with cardiorespiratory fitness (0.237, p=0.009) with weak strength. Physical activity levels had a moderate positive correlation with cardiorespiratory fitness (0.263, p=0.005). Total body fat showed no significant correlation with cardiorespiratory fitness (0.013, p=0.885). A negative correlation with weak strength was found on visceral fat and cardiorespiratory fitness (-0.193, p=0.022). Muscle mass had moderate, positive correlation with cardiorespiratory fitness (0.399, p=0.000). Our study showed no significant relationship between sleep quality (-0.001, p=0.995), lung vital capacity (VC) (0.050, p=0.811), and chronotype (-0.144, p=0.100) with cardiorespiratory fitness.

4. Discussion

Our study found that less than one fifth of participants exhibit normal cardiorespiratory fitness. This is concerning as poor cardiorespiratory fitness is linked to a higher risk of cardiovascular diseases, diabetes, and other chronic health conditions. Additionally, it can negatively impact cognitive function, mental health, and overall physical well-being [3]. For medical students, who often face high levels of stress and demanding schedules, maintaining good cardiorespiratory fitness is crucial for managing these challenges effectively [2]. The implications of this finding suggest a need for targeted interventions to promote physical activity and improve fitness levels among medical students, ultimately enhancing their health, academic performance, and future ability to care for patients [15].

Our research findings indicate a statistically significant relationship between gender and cardiorespiratory fitness among medical students. These results are supported by previous studies, which found that gender correlates with cardiorespiratory fitness, with female students exhibiting a higher correlation coefficient compared to male students. The difference in fitness levels between genders can be attributed to hormonal factors, specifically testosterone and estrogen. Testosterone, through its conversion to 5α-dihydrotestosterone, enhances cellular metabolism, mitochondrial function, and ATP production, thereby contributing to higher fitness levels in males. Conversely, females, with lower testosterone levels and higher estrogen levels, may experience different fat distribution patterns affecting BMI and fitness levels [16].

Moreover, previous study shows that males generally have greater lung and vital capacities compared to females, which can influence overall cardiorespiratory fitness [17]. Physical activity levels also demonstrate a significant correlation with cardiorespiratory fitness, supported by research indicating a positive connection between physical activity and cardiorespiratory fitness in individuals at risk of metabolic diseases [18]. Additionally, previous studies have highlighted the significance of regular exercise and routine physical activity in improving cardiorespiratory fitness [5,6,19].

Based on earlier research, there is a correlation between body mass index (BMI) and cardiorespiratory fitness. Overweight female students exhibited decreased cardiorespiratory fitness [20]. Similarly, other studies demonstrated a negative correlation between BMI and cardiorespiratory fitness, suggesting that higher BMI reduces cardiorespiratory capacity. This relationship shows the importance of maintaining a healthy weight through adequate physical activity to maintain cardiovascular and respiratory system function [21].

The positive correlation between muscle mass and cardiorespiratory fitness was also shown in this study, as demonstrated by previous study, attributing increased muscle mass to improved oxygen delivery and energy production during physical activity. Sarcopenia, which can be developed in a later life stage as a result of a sedentary lifestyle, may reduce physical ability and cardiorespiratory fitness, leading to poor quality of life [22].

Similarly, the negative correlation between visceral fat and cardiorespiratory fitness aligns with previous study. Excess visceral fat is detrimental for cardiorespiratory function because it is located around vital organs such as the heart and lungs, which places additional strain on the body. It is also associated with increased inflammation and insulin resistance, which can contribute to cardiovascular and respiratory diseases [23].

Our findings of the significant relationship between cardiorespiratory fitness with both systolic and diastolic blood pressure underscore the impact of fitness on vascular health. Surprisingly, several studies have highlighted a similar positive correlation between blood pressure and physical fitness. Due to the acute effects of physical activity on blood pressure measurements or the body's adaptive response to regular exercise, temporary increases in blood pressure can lead to improved overall cardiorespiratory fitness and muscle strength despite transient spikes during activity [24]. However, it is crucial to differentiate between these acute, temporary increases in blood pressure during exercise and chronic hypertension [25]. As our respondents consist solely of late adolescents (aged 18-21), further study is needed to assess this relationship in different age groups and more comprehensively understand the long-term implications of hypertension.

Our study failed to find a significant relationship between lung vital capacity and cardiorespiratory fitness among the medical students, contrasting with previous research [26]. This can be caused by several factor such as inaccuracies in measurement techniques or variability in testing protocols, since spirometry results depend on participants' understandings. Individuals with similar total lung capacity values may exhibit varying levels of fitness based on factors like aerobic capacity, muscle fitness, and overall cardiovascular health. Other factors such as lung diffusion capacity, pulmonary ventilation, and respiratory muscle strength may have a more direct influence on cardiorespiratory fitness.

Conversely, sleep quality does not show a significant relationship with cardiorespiratory fitness among medical students. This aligns with findings from previous studies which found no significant correlation between sleep quality and physical fitness [7, 27]. Additionally, there are studies that did not reveal a relationship between chronotype and physical performance, which is in line with our findings [28, 29]. This could be attributed to the complexity of an individual's biological clock, which may be influenced by various factors such as genetics, environmental cues, lifestyle, and social habits. While some studies suggest a link between chronotype and health outcomes, including cardiovascular health, the relationship may not be straightforward. Factors like sleep duration, sleep quality, and overall lifestyle habits may overshadow the direct impact of chronotype on cardiorespiratory fitness.

Lastly, this study is not without limitations. Cross-sectional studies can only establish associations between variables at a single point in time, making it difficult to infer causality. This study may also be susceptible to selection bias, as participants are recruited from specific populations, which may not represent the condition of the general population. Data which is self-reported may be subject to recall bias or social desirability bias. Our study may not account for all potential external factors that could influence cardiorespiratory fitness, such as environmental pollutants, occupational exposures, or psychosocial stressors. Further research incorporating additional variables and additional sample sizes is recommended to enhance the understanding of cardiorespiratory fitness.

5. Conclusions

Our study reveals that majority of medical students exhibit poor cardiorespiratory fitness. This study highlights significant associations between cardiorespiratory fitness and multiple variables such as gender, physical activity, BMI, muscle mass, visceral fat, and blood pressure, emphasizing the need for targeted interventions to improve fitness levels. Although no significant relationships were found with sleep quality and chronotype, this may be due to the complexity of these factors and their indirect effects on cardiorespiratory fitness. Understanding these relationships can inform targeted interventions to improve cardiorespiratory health among medical students and highlight the importance of regular physical activity and healthy lifestyle choices. Further research incorporating additional variables and larger sample sizes is recommended to enhance the understanding of cardiorespiratory fitness determinants and their implications for health outcomes.

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