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RESEARCH ARTICLE

Correlation Between Total Body Fat and Physical Fitness Index in Medical Students

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ABSTRACT

Introduction: According to the World Health Organization, total body fat is one of the main risk factors for metabolic syndrome, which is the most significant cause of morbidity and mortality in the world. The excessive fat mass harms the function of the heart, lowers the oxygen uptake by working muscles and decrease physical fitness. **Objective:** This research was aimed to determine the correlation between total body fat and physical fitness index in medical students.

Methods: This was a cross-sectional study in 45 male medical students of Universitas Islam of Indonesia under 25 years old. The total body fat percentage (TBF) was measured by the bioelectrical impedance analysis method (Karada's scan), while the physical fitness index was examined by the Harvard step test. The data were analyzed by Spearman's correlation test.

Results: The mean of TBF and physical fitness index levels was 23.68 ± 6.29 and 60.05 ± 31.27 , respectively. Spearman correlation test resulted in $r = -0.314$ with a significance of $p = 0.038$ ($p < 0.05$), meaning that total body fat and physical fitness index has a significant negative correlation.

Conclusion: There was a significant negative correlation between total body fat and physical fitness index.

Keywords: Total body fat, physical fitness index, bioelectrical impedance analysis

ABSTRAK

Pendahuluan: *World Health Organization* menyatakan bahwa total lemak tubuh adalah salah satu faktor risiko utama untuk sindrom metabolik yang merupakan penyebab paling signifikan morbiditas dan mortalitas di dunia. Massa lemak berlebihan dapat merusak fungsi jantung, menurunkan penyerapan oksigen oleh otot-otot yang bekerja, serta dapat menurunkan kebugaran fisik. **Tujuan:** Penelitian ini bertujuan untuk mengetahui hubungan total lemak tubuh dengan indeks kebugaran jasmani pada mahasiswa kedokteran Universitas Islam Indonesia.

Metode: Penelitian ini menggunakan desain penelitian cross-sectional. Subjek penelitian terdiri dari 45 mahasiswa kedokteran pria Universitas Islam Indonesia yang berusia di bawah 25 tahun. Total lemak tubuh subjeknya diukur dengan metode Analisis Impedansi Bioelektrik (Karada scan), sedangkan indeks kebugaran fisik diukur dengan Harvard Step Test. Penelitian ini diuji dengan korelasi Spearman.

Hasil: Nilai rata-rata TBF (%) adalah $23,68 \pm 6,29$. Rerata tingkat indeks kebugaran fisik adalah $60,05 \pm 31,27$. Uji korelasi Spearman memiliki hasil $r = -0,314$ dengan signifikansi $p = 0,038$ ($p < 0,05$), itu berarti total lemak tubuh dan indeks kebugaran fisik memiliki korelasi negatif yang signifikan.

Kesimpulan: Ada korelasi negatif yang signifikan antara total lemak tubuh dan indeks kebugaran fisik.

Kata Kunci: Total lemak tubuh, indeks kebugaran fisik, analisis impedance bioelektrik

INTRODUCTION

Total body fat is one of the main risk factors for metabolic syndrome (central obesity, dyslipidemia, hypertension, diabetes) which is the most significant cause of morbidity and mortality in the world. The most common problems related to increase in body fat is obesity (Alappat and Awad, 2010; Piché *et al.*, 2018). The data published by the Centers for Disease Control and Prevention (CDC) in 2017 showed that 30.2 million people aged over 18 years and 12.2% of adolescents in the USA experience metabolic syndrome, especially those who have type 2 diabetes and obesity (Saklayen, 2018). WHO defined obesity as the presence of abnormal or excessive fat accumulation that poses a bad risk to health (Saklayen, 2018). The National Health and Nutrition Examination Survey (NHANES) in 2009-2010 states that the prevalence of the obese population in the United States account for 69.2% of all adults aged 20 years and over. This grouping shows about 35.5% of adult men and 36.6% of adult women (Aggarwal, 2010; Alappat and Awad, 2010).

Obesity is associated with higher health risks. In May 2012, WHO stated that there were 2.8 million deaths of adults each year worldwide due to obesity. NHANES data shows a link between the total amount of body fat and death in adults in the United States associated with obesity. It is estimated that about 112,000 deaths in the United States are related to obesity. Studies shows that in the United States obesity accounts for 14% and 20% deaths mean in men and women, respectively (Aggarwal, 2010; Shazia *et al.*, 2015).

The excessive fat accumulation in obese people cause inflammation. It also affects the other hormone activity, such as insulin, associated to increased risk metabolic syndrome leading to increased risk of coronary heart disease. The excessive adipose tissue associated with progression of diseases and is strengthened by a factors of age and low physical activity (Chang *et al.*, 2012).

Excessive fat mass may cause unfavorable burden on heart and blood vessel function, as well as oxygen uptake by working muscles. Thus, subjects with high total body fat can experience a decrease in physical fitness due to a decrease in endurance and effectiveness of the cardiorespiratory, a decrease in the ability to take up oxygen in the muscles. This can have a dual effect on subjects with poor health, which can lead to an increase in the progression of metabolic syndrome. Even worse, this excessive fat accumulation can cause a decrease in bodily function, disability, and even death (Chang *et al.*, 2012).

Studies have shown the role of total body fat in one's physical fitness level. Previous research states that fat in the body, especially visceral fat is associated with a risk of cardiovascular disease and metabolic syndrome. In addition, according to previous research there is a significant negative correlation between health related fitness indicator and total body fat in students. Therefore, this study aims to determine the relationship between total body fat with physical fitness index (Bradbury *et al.*, 2017; Muka *et al.*, 2017). A

similar previous research was conducted in older subject. This research involved younger subject as participant.

METHODS

This was a cross-sectional study. The research was carried out in the physiology laboratory of the Faculty of Medicine of the Islamic University of Indonesia in the final period of 2018 to 2019. The number of research subjects was 45 taken using a correlative large sample formula:

$$N = \frac{(Za + Zb)^2}{0.5 \ln \left[\frac{(1+r)}{(1-r)} \right]} + 3$$
$$N = \frac{(1,64+1,28)^2}{0.5 \ln \left[\frac{(1+0,45)}{(1-0,45)} \right]} + 3$$
$$N = 44,84$$
$$N = 45$$

The inclusion criteria were active students of the Faculty of Medicine, Islamic University of Indonesia, male, not smoking, not an athlete, and willing to take part in the research. The exclusion criteria were history of heart diseases (acute coronary syndrome, congenital heart disease, and high blood pressure), digitalis therapy or hypokalemia, lung disease. There was only one group in this research.

Total Body Fat Measurement

The independent variable of this study was total body fat measured by the bio impedance analyze (BIA) method using a karada scan. The karada scan used in this research was calibrated. The subject stand on the karada scan for about 5 minutes, the data will be shown on the screen.

Physical Fitness Measurement

The dependent variable was the index of physical fitness measured using the Harvard step test. Harvard step up test was carried out using a bench as high as 40 cm. Participants rest for 5 minutes before conducting the test. The test was done with a tempo of 120 x/minute up to a maximum of 5 minutes or participants experience fatigue. Data obtained from the Harvard step test were how long the subject took the test and the number of pulses of the subject for 30 seconds after a break of one minute then entered into the physical fitness index formula.

Statistical Analysis

The data obtained was then subjected to data normality test with the Shapiro-Wilk test. Total body fat and physical fitness index are not normally distributed. After testing the linearity assumption, the relationship between total body fat and physical fitness index was linear. Therefore, the correlation test used is the Spearman correlation test. The result was considered significant when $p < 0.05$.

RESULTS

This research obtained ethical clearance from ethics committee of the Faculty of Medicine, Islamic University of Indonesia (1/Ka.Kom.Et/70/KE/X/2018).

Table 1. Characteristic of subjects

Characteristics	N	%
Age (years)		
20	1	2.2%
21	2	4.4%
22	8	17.7%
23	21	46.6%
24	13	28.8%
Gender		
Male	45	100%
Bachelor (semester)		
4 th	14	31.1%
3 rd	21	46.6%
2 nd	10	22.2%

The research subjects consisted of 45 students of the Faculty of Medicine, Universitas Islam Indonesia. All the subjects were men. The average age of the subjects was 20.60 ± 0.14 years. The average value of total body fat and physical fitness index of respondents $23.68 \pm 6.29\%$ and 60.05 ± 31.27 , respectively, shown in table 2. Spearman's correlation test between total body fat and physical fitness index resulted in $p < 0.05$ showing significant relationship between ($p < 0.05$). The correlation coefficient value was -0.314 meaning there was a negative correlation in which the higher the total value of a person's body fat, the lower the value of the person's physical fitness index will be.

Table 2. Relationship of Total Body Fat and Physical Fitness Index

Variable	Mean	Spearman Correlation	P value
Total Body Fat	$23.68 \pm 6.29\%$	- 0.314	0.038
Physical Fitness Index	60.05 ± 31.27		

Correlation is significant at: P value < 0.05 level

DISCUSSIONS

This research was conducted with a sample of 45 male respondents with an age ranging between 18 and 22 years. The respondents had same sex, because gender can influence the physical fitness index, this has been proven in a cross-sectional study of populations in India that take measurements of the physical fitness index using the Harvard step test. The study states that the male physical fitness index is significantly higher than that of women (Parmar *et al.*, 2016). Similar research conducted by Muka *et al.*,

states that there are differences in total body fat between men and women. The study showed that the percentage of fat in women is greater than men. This is caused by puberty, women experience twice the accumulation of more fat which serves to protect organs. While men at puberty experience muscle development. Therefore, this study only used male subjects (Muka *et al.*, 2017).

This study showed that there is a statistically significant relationship between total body fat with physical fitness index. This is evident from the results of the Spearman test conducted on two variables. The *p*-value obtained from this test was 0.038 ($p < 0.05$). The correlation coefficient value -0.314, which means it has a negative correlation direction in which the higher the total body fat value, the lower the physical fitness index value of the person will be. The result is inline with research of Peter *et al.*, (2010) which indicates that there is a significant or significant relationship between total body fat with physical fitness index with a negative correlation direction, which means there is a negative relationship between total body fat with physical fitness index (Pribis *et al.*, 2010).

The decrease in physical fitness index caused by total body fat is related to several things. One study conducted on 200 children at the Bijapur School, North Karnataka, India, aged 12-16 years, stated that there was a significant relationship between total body fat and physical fitness index in children. Correlation relationships obtained in the form of a negative correlation. As such, total body fat accumulation is associated with a decrease in physical fitness index, which has been estimated to occur since children (Khodnapur *et al.*, 2012).

The total fat in a person's body increases with an increase of age, especially in men. There will be a buildup of fat in the internal fat tissue related to non-adipose organs such as skeletal muscles, pancreas, liver, and heart (Piché *et al.*, 2018). Fat distribution in men and women tend to be different. Men tend to accumulate fat in the viscera and internal, whereas women tend to accumulate fat in the gluteal region (Thomas *et al.*, 2013).

This finding supports the study conducted by Sharma *et al.*, in 30 subjects aged 25-35 years of staff of the Faculty of Medicine in India. Results stated that there was a relationship between total body fat with physical fitness index conducted using the queen's college step test. This test is similar to the Harvard step test using a 41.30 cm beam board with a rhythm 24x per minute using a metronome. The results showed a negative correlation with a high correlation, with the result ($P = 0.046$ with a correlation coefficient $R = -0.929$). This proves that with increasing age there will be an increase in total body fat which causes an increase in overload on the heart (Farideh and Maryamalsadat, 2016; Sharma *et al.*, 2016).

The total body fat mechanisms is associated with the physical fitness index. Excessive body fat can cause decreased endurance and effectiveness of cardiorespiratory through various mechanisms such as insulin resistance, increased pro-inflammatory cytokines, and increased prothrombin activator inhibitors. Besides, the presence of excessive total body fat can put a heavy burden on the heart, due to increased LDL and decreased HDL (Teresa *et al.*, 2018). One of the mechanisms is through the increase of free fatty acids from adipose cells which creates obstacles to the transportation of glucose from the blood to various organs such as the heart, lungs, and muscles. As a result, the heart and lungs cannot function optimally in terms of the ability of the circulation and the respiratory system. This causes the supply of oxygenated blood to muscle cells during physical activity to decrease (Sharma *et al.*, 2016; George Bakris *et al.*, 2018).

In the event of deposition of high-fat mass will cause the muscles to fail to take insufficient oxygen, causing the muscles to not be able to optimally eliminate the effects of fatigue after activity and cause a decrease in muscle ability (Sharma *et al.*, 2016; George Bakris *et al.*, 2018). Increased free fatty acids in the body cause cell oxidative stress caused by increased mitochondrial ROS and the activity of the enzyme NADPH oxidase. This results in increased expression of angiotensinogen mRNA (Sukamti *et al.*, 2016).

The mechanism of increasing angiotensinogen levels in adipocyte cells is thought to be through biochemical pathways due to increased ROS. The first mechanism, which is polyol pathway activity, will cause an increase in the production of toxic sorbitol, which in turn activates the p38 MAPK enzyme. The p38 MAPK enzyme activates transcription factors that play a role in the expression of angiotensinogen genes (Mexitalia *et al.*, 2012). The adverse effect due to increased levels of angiotensinogen in the blood is an increase in the activity of the renin-angiotensin-aldosterone system which always makes vasoconstriction of blood vessels. contains oxygen to muscle cells during physical activity (Zanovec *et al.*, 2010; Teresa *et al.*, 2018).

Another mechanism for the influence of total body fat with physical fitness index is through the decreased endothelial function of blood vessels. Endothelial functions include the functional capacity of endothelial cells in the synthesis and release of nitric oxide (NO). With an increase in adipose tissue, it causes a reduction in synthesis and availability of NO which causes an increase in vascular permeability, inflammation, adhesion, thrombosis in blood vessel circulation, and decreases the ability of blood vessel vasodilation (Teresa *et al.*, 2018).

Other mechanisms, namely the release of IL-6 cytokines, TNF α by visceral fat can trigger inflammatory reactions, increased prothrombin activator inhibitor-1 from adipose cells that play an important role in the process of coagulation and endothelial dysfunction which ultimately worsens the circulation system in the body. The combination of several mechanisms above harms the level of cardiorespiratory fitness because it can interfere with the function of the heart, blood vessels, lungs in terms of taking oxygen needed by the body (Mexitalia *et al.*, 2012; Teresa *et al.*, 2018).

Peter *et al.*, conducted a descriptive study among 5101 students using the MicroFit test from 1996 to 2008 during gym class. This research showed that there is a significant positive linear relationship between total body fat and age. On average in 13 years, body fat increased by 0.513% in men and 0.654% in women. Due to increased total body fat, this study also showed that there was a decrease in physical fitness index, with $P < 0.001$ with $r = -0.498$ for men (Pribis *et al.*, 2010).

Body weight is negatively correlated and has a weak correlation strength with physical fitness index. Theoretically, the results of this study showed that the greater the weight value, the smaller the physical fitness index value. In the research of Khodnapur *et al.*, it was proven that there was a negative correlation between body weight and moderate physical fitness index. The heavier the weight, the greater the composition of body fat contained in a person's body. Research by Shazia, Badaam, and Deore, found a linear relationship between body weight and total body fat. In other words, high-fat content will reduce the value of one's physical fitness index (Xu *et al.*, 2012; Shazia *et al.*, 2015).

For further research, direct measurement needs to be done to assess the factors that can affect the physical fitness index value such as Hb levels, physical activity scores, impaired cardiorespiratory function,

and motor and/or mobility disorders. Also, it is necessary to spread the age of research subjects more evenly in the young adult age group so that the effect of age on the physical fitness index can be determined.

CONCLUSIONS

There is a significant relationship between total body fat with physical fitness index with a negative correlation direction, where the higher the total body fat, the lower the physical fitness index will be.

CONFLICT OF INTEREST

The authors declare no conflict of interest during manuscript production.

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