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The Association Between Fat Free Mass and Basal Metabolic Rate with Handgrip Strength in Female Medical Students

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Abstract

Handgrip strength is an indicator of general muscle strength. Low handgrip strength is associated with various diseases that can increase morbidity and mortality. Fat free mass and basal metabolic rate are indicators of health and physical fitness. Low physical activity and degenerative changes in muscle strength in female medical students may be risk factors for cardiovascular disease, metabolic syndrome, and sarcopenia in old age. The aim of this study was to determine the association between fat free mass and basal metabolic rate with handgrip strength in female medical students. The type of research includes observational analytics with a cross-sectional design on 54 samples selected using purposive sampling techniques. Fat free mass and basal metabolic rate data were collected using a bioelectrical impedance analysis tool, handgrip strength using a handgrip dynamometry tool which was carried out directly. Statistical data analysis used the Independent sample t-test and Chi-square test. The results of the analysis using the Independent sample t-test found that there was no significant difference based on fat free mass between respondents with low handgrip strength and normal handgrip strength ($p = 0.662$) and there was a significant association between basal metabolic rate and handgrip strength ($p = 0.001$) with an odds ratio (OR) of 16.875. Female medical students need to maintain activity performance, train muscle strength, and adopt a healthy lifestyle so that handgrip strength, fat-free mass, and basal metabolic rate are maintained.

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INTRODUCTION

Handgrip strength is an indicator of overall muscle strength using the maximum grip force that can be produced during muscle contractions (Bae et al., 2019). Handgrip dynamometry is a tool to measure handgrip strength used to estimate the body strength and overall health conditions. Handgrip strength can help predict and identify an individual lifelong health status (Zaccagni et al., 2020). Decreased handgrip strength is associated with various diseases that can increase the morbidity and mortality from cardiovascular risks. As a person ages, the muscle strength will decrease, so it is important to maintain the muscle strength as it is one of the physical fitness components (Confortin et al., 2022). A study conducted by the Asian Working Group for Sarcopenia (AWGS) found that Asian populations had a prevalence of low physical performance, low muscle mass, and low strength, ranging from 4.1% to 11.5%. The poor muscle mass was shared by 22.1% of men and 21.8% of women in Asia. The prevalence of sarcopenia in Indonesia was found to be very high, reaching 9.1% (Vitriana et al., 2016). Considering the low muscle strength and a poor prevalence, understanding decreased muscle strength as a risk factor for type 2 diabetes mellitus, cardiovascular disease, metabolic syndrome, and sarcopenia would be beneficial (Jaramillo et al., 2022).

Muscle strength is highly dependent on the nature of the base material. Any particular change in the base material as a result of fat inclusions in the muscle fibers leads to a decrease in the strength and quality of the resulting muscle. The level of intramuscular fat also has a significant influence on the overall muscle strength that will be produced (Rahemi et al., 2015). Fat free mass (FFM) consists of muscles, organs, bones, and body fluids. Fat free mass, as an indicator of health and physical fitness, is part of body compositions (Nurdin, 2020). A research in India found a positive relationship between fat free mass and handgrip strength (Acharya et al., 2022). Fat free mass is a major determinant of basal metabolic rate (BMR), accounting to 50 – 70% amount of energy required for the body to perform essential activities at rest (Oh et al., 2019). Basal metabolic rate is important for assessing health conditions and human body status (Liu et al., 2017). A study conducted in Korea on elderly respondents found that handgrip strength and basal metabolic rate also had a positive relationship (Oh et al., 2019).

Medical students are less physically active than non-medical students (Naim et al., 2016). Weakened muscle strength can be caused by decreased physical activity (Amanah & Citrawati, 2020). A decrease in activity levels, such as walking, can cause a higher risk of sarcopenia, particularly for middle-aged women and older populations (Ahn et al., 2019). Degenerative changes in muscle strength also occur much earlier in women than in men (Dodds et al., 2014). Muscle weakness can be a risk factor for cardiovascular disease, metabolic syndrome, type 2 diabetes mellitus, and sarcopenia in old age. An early identification of factors affecting the handgrip strength and weakness is important so that the prevention can be carried out as soon as possible (Lopez-Jaramillo et al., 2022). Based on this explanation, researchers were interested in examining the correlation between fat free mass and basal metabolic rate with handgrip strength, particularly in female medical students that usually have a lack of physical activity degree and a lower basal metabolic rate compared to male students. Research examining the correlation among fat free mass, basal metabolic rate, and handgrip strength is still limited in Indonesia, mirroring the lack of this topic in developing countries. This study is crucial to gain insights into the future medical staffs, particularly female students in the health sector.

METHODS

This research is a quantitative research using the observational analytic method and cross sectional design. Ethical approval for this research has been obtained from the Health Research Ethics Commission of the Universitas Pembangunan Nasional "Veteran" Jakarta with number: 374/X/2023/KEP.

Participants

The research samples were taken from active Undergraduate Medical students of the Faculty of Medicine, Universitas Pembangunan Nasional "Veteran" Jakarta, who met the inclusion criteria. The inclusion criteria included age of 18-22 years, normoweight body mass index (BMI), moderate physical activity, not in a state, having received an explanation about the research, and willing to become respondents. Exclusion criteria of this study were students with a history of upper extremity dysfunction, a history of neurological and motor disorders in the upper extremities, a history of rheumatoid arthritis, and a history of thyroid disease.

Sampling Procedures

The number of samples of this study were 54 respondents taken using the nonprobability method by purposive sampling. Sampling was carried out by distributing questionnaires to the population, then selecting samples that met the inclusion criteria. The research was conducted from February to December at the Physiology and Nutrition Unit located in the Medical Education and Research Center building of Universitas Pembangunan Nasional "Veteran" Jakarta, Jl Limo Raya No. 7, Cinere, Depok.

Procedures

The researchers distributed a google form regarding the personal identity such as name, age, and telephone number along with other criterias assessed in this study such as weight, height, physical activity level, and the history of thyroid or rheumatoid arthritis disorders, recent trauma, neurological disorders, or upper level extremity dysfunctions. The 54 participants were active undergraduate female medical students at Universitas Pembangunan Nasional "Veteran" Jakarta aged 18-22 years with normoweight body mass index (BMI) and moderate physical activity with no pathological disorder on upper extremities or metabolical dysfunctions. The 54 participants had given their consent to take part on this research. The measurement of physical activity inclusion criteria used the Global Physical Activity Questionnaire (GPAQ) and the measurement of fever used a tympanic thermometer. Handgrip strength was measured using handgrip dynamometry. The measurement began with setting the handgrip dynamometry to zero (0), adjusting the tool to the participant hand, turning the handle to move it up or down, and asking the respondent to hold the tool with the dominant hand in standing position. The respondents gripped the handgrip dynamometry as hard as possible for 3 seconds. Then, the results of handgrip strength were read and recorded in kilograms (kg).

Fat free mass and basal metabolic rate were measured using bioelectric impedance analysis (BIA), TANITA MC-980MA Plus. Respondents were asked to remove objects that could affect the assessment. Then, respondents stood barefoot and grasped two electrodes on the device. Safe and low electrical signals were sent by the electrodes throughout the body in a standing position for 30 seconds. Subsequently, the data were printed and analyzed for fat free mass in kilograms (kg) and basal metabolic rate in kcal (kilocalories).

Design or Data Analysis

The analysis of fat free mass difference based on the handgrip strength used the Independent sample t-test. The association between basal metabolic rate and handgrip strength used the Chi-Square test.

RESULT

Table 1 shows the characteristics of respondents, including the average body weight (46.742 kg), the average height (1.573 meters), and the average body mass index (21.155).

Table 1. Average Weight, Height, and Body Mass Index

Measurement	Average (standard deviation)
Body weight (kg)	46.742 (±17.073)
Height (m)	1.573 (±0.034)
IMT	21.155 (±1.388)

Table 2. shows that the 2021 batch respondents had a higher average fat free mass than other batches, namely 35.950 with a standard deviation of 2.460.

Table 2. Average Fat Free Mass

Measurement	Average (standard deviation)
2020	35.659 ± 1.927
2021	35.950 ± 2.460
2022	35.200 ± 2.605
Overall	35.638 ± 2.153

Table 3 shows that most of the respondents had a high basal metabolic rate (51.9%), not much different from those with a low basal metabolic rate (48.1%).

Table 3. Frequency Distribution of Basal Metabolic Rate

Basal Metabolic Rate	Frequency	%
Low	26	48.1
High	28	51.9
Total	54	100

Table 4 shows that most of the respondents (43 participants or 79.6%) had a normal handgrip strength category. The frequency was almost four times of the low handgrip strength category.

Table 4. Frequency Distribution of Handgrip Strength

Handgrip Strength	Frequency	%
Low	11	20.4
Normal	43	79.6
High	0	0
Total	54	100

Table 5 shows that the Independent sample t-test test obtained a p-value = 0.662 (p>0.05) meaning that there was no significant difference of fat free mass between the low handgrip strength respondents and the normal handgrip strength respondents.

Table 5. Fat Free Mass Difference based on Handgrip

Handgrip Strength	Average		P-value
	n	Fat Free Mass	
Low	11	35.381	0.662
Normal	43	35.704	

Table 6 shows that the Chi-square test obtained a p -value of 0.001 (p <0.05), concluding that there was a statistically significant association between basal metabolic rate and handgrip strength with an odds ratio (OR) of 16.875 indicating that respondents with a normal handgrip strength had a 17 times higher risk of experiencing a high basal metabolic rate.

Table 6. Correlation between Basal Metabolic Rate and Handgrip Strength

Basal Metabolic Rate	Handgrip Strength				Total		P-value
	Low		Normal				
	n	%	n	%	n	%	
Low	10	37	16	61.5	6	100	0.001
High	1	3.7	27	96.4	48	100	
Total	11	20.4	43	79.6	54	100	

DISCUSSION

The results of the study showed that, even though there was a statistically significant correlation between BMR and handgrip strength, the fat free mass and handgrip strength was not the same case. There were several factors that contributed to this discovery that will be elaborated further in each paragraph.

The results of this study showed that respondents had an average body weight of 46.742 kg with a standard deviation of 17.073, an average height of 1.573 with a standard deviation of 0.034, and an average body mass index of 21.155 with a standard deviation of 1.388. The average fat free mass of respondents was 35.638 ± 2.153.

The results showed that the average value of fat free mass in respondents was 35.638 ± 2.153. The average fat free mass in Class of 2020 students was 35.659 ± 1.927, Class of 2021 students was 35.950 ± 2.460, and Class of 2022 students was 35.200 ± 2.605. Class of 2021 students had the highest average fat free mass. This finding is in accordance with the dominant hormones acting on each female and male adolescent related to the development of fat free mass, particulary the muscle due to the influence of the dominant testosterone hormone in men. Fat free mass is associated with a good physical and cardiorespiratory fitness as an important predictor of the current and future health. Higher levels of fat free mass may increase the sensitivity to insulin, which contributes to the uptake of glucose by muscles thus preventing excessive glucose spikes after meals (Ciardullo et al., 2023; Henriksson et al., 2016; Kasović et al., 2021).

Based on the results of univariate analysis of the handgrip strength (HGS) variable, it was found that the majority of respondents had a normal handgrip strength (79.6%). The normal handgrip strength can be used as a key biomarker of healthy aging and a strong predictor of quality of life against future morbidity and mortality in both young and older adult populations. Muscle strength is influenced by muscle contractions that occur when there is a cross-bridge interaction between actin and myosin through a filament shift mechanism, resulting in an increase in muscle fibers and metabolism (Confortin et al., 2022; Morlino et al., 2021; Tortora & Derrickson, 2017). A low handgrip strength is correlated with several medical diseases, including the chronic anemia, dyslipidemia, hypertension, metabolic syndrome, and chronic kidney diseases. It is also associated with food intakes and diets (Lee, 2021; Wiśniowska-Szurlej et al., 2021).

The results showed that the fat free mass of respondents in the low handgrip strength group obtained an average of 35.381 kg, while the fat free mass of respondents in the normal handgrip strength group gained an average of 35.704 kg. Independent sample t-test results obtained a value of p = 0.662 (p>0.05), meaning that there was no significant difference of fat free mass between the low handgrip strength respondents and the normal handgrip strength respondents. Body mass is divided into two main components, namely fat mass and fat free mass. Skeletal muscle mass, which is a constituent of fat free mass, is associated with muscle strength. A decrease in fat free mass can inhibit the activation of muscle motor centers and produce inflammatory cytokines, such as TNF-α, causing a decrease in muscle strength. However, muscle mass is not the only component of fat free mass and there are other factors such as bones, organs, and fluids that contribute to fat free mass (Henriksson et al., 2016; Nonaka et al., 2018; Westerterp et al., 2021).

The lack of influence of fat free mass on handgrip strength may be because the participants of the study were female. Women have lower upper limb muscle mass than men and have more fat mass, so they tend to have a weaker muscle strength. Women have the hormone estrogen which causes subcutaneous fat accumulation so that the fat mass influence is more likely to affect the hangdrip strength. Fat mass negatively affects muscle mass because the resulting inflammatory response triggers catabolic reactions in the muscle, which can reduce the muscle mass and strength (Ahn et al., 2019; Acharya et al., 2022; Shah et al., 2022; Steiner & Berry, 2022).

Handgrip strength plays a role in evaluating the nutritional status by measuring the muscle strength. Handgrip strength is not only influenced by fat free mass. Other factors are more influential in female respondents, such as dominant upper arm muscle area, fat mass, arm fat index, palm circumference, forearm circumference, hand length, wrist joint circumference, and middle finger length. The effect of insulin resistance also plays a role in decreasing the muscle strength in obese cases. This difference in results may be influenced by other external factors that are not yet fully understood, such as lifestyle, food and beverage consumptions, and variations in the hormone action interaction between individuals (Shah et al., 2022; Stenholm et al., 2011; Zaccagni et al., 2020).

Based on the data, some respondents had a high basal metabolic rate category (51.9%). A high basal metabolic rate indicates that individuals have a good metabolism so that they need more calories to maintain body functions during resting conditions, such as breathing, heart rate, and nervous system communications. Although basal metabolic rate is influenced by various factors, such as gender, age, physical activity, nutritional status, muscle mass, growth hormone, thyroid hormone, body temperature, and body composition, all female respondents in this study were similar in age and physical activity. Basal metabolic rate values are entirely dependent on the factors, such as nutritional status and body compositions. Having more muscle mass than fat increases the basal metabolic rate (Han et al., 2022; Kang et al., 2021; McNab, 2019; Munawaroh, 2021; Verma et al., 2023).

The results of this study indicated that respondents with low basal metabolic rate and high basal metabolic rate categories mostly had normal handgrip strength, namely 61.5% and 96.4%. Based on the results of the Chi-square test analysis, the p-value was 0.001 ($p < 0.05$), concluding that there was a statistically significant association between basal metabolic rate and handgrip strength with an odds ratio (OR) of 16.875, meaning that the respondents with a normal handgrip strength had a 17 times higher risk of experiencing a high basal metabolic rate. The association between basal metabolic rate and handgrip strength was positive, complex, and multifaceted. Muscle strength training can increase the number of capillaries, increase mitochondrial biogenesis, metabolic stress, and growth hormone production, causing the basal metabolic rate to increase. Mitochondrial biogenesis is the process by which new mitochondria are generated from existing mitochondria, leading to an increase in the number of mitochondria in the cell. This process is important for increasing the basal metabolic rate as mitochondria are responsible for producing energy in the form of ATP. The higher the energy that can be expended the higher the amount of strength that can be expressed in a short period of time. High values of handgrip strength along with muscle mass contribute to the increase of BMR as the muscle needs energy for daily functional activities (Oh et al., 2019; Popov, 2020). Therefore, a lower basal metabolic rate can be an early predictor of osteoporosis and sarcopenia in women (Maghbooli et al., 2022), becoming a great hindrance of medical issues for future female doctors having less BMR.

CONCLUSION

Based on the result of this research, there was no association between fat free mass and handgrip strength in respondents, which could be caused by other factors that could more significantly affect the handgrip strength. There was an association between basal metabolic rate and handgrip strength in respondents. During the process of collecting handgrip strength data, there were several factors that could not be controlled by the researchers, such as genetic factors and a definite diagnosis of the presence or absence of diseases or other factors affecting the handgrip strength, because the researchers only eliminated these diseases by asking the respondents for the history, not by a direct examination. There was also no pilot study prior to the main experiment that could be utilized to validate the respondent understanding toward the distributed questionnaires and certainty to assess regular sport activities of participants involving gripping mechanism. Future researchers are advised to explore a more detailed information about potential confounding factors that can affect the final results, such as eating and drinking habits as a source of energy, along with the usual habits involving the upper extremity strength build-up. Respondents are advised to maintain a healthy lifestyle and good physical activity performance to maintain an optimal muscle strength, fat free mass, and basal metabolic rate. The medical faculty can create teaching and learning activities that are balanced between indoor and outdoor activities, for example the lectures interspersed with joint sport activities.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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