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ORIGINAL ARTICLE

Body mass index and muscle strength in medical students

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ABSTRACT

Body mass index (BMI) is an indicator of nutritional status that affects health and muscle strength. Obesity inhibits adenosine monophosphate activated protein kinase (AMPK), thereby reducing endurance, decreasing muscle function, and increasing disease risk. This study aims to determine the relationship between BMI and muscle strength. A cross-sectional analytical study was conducted among preclinical students of the Faculty of Medicine, Universitas Jenderal Achmad Yani. BMI, grip strength, and standing long jump performance were measured in all respondents. Data were analyzed using Statistical Product and Service Solutions (SPSS). The results showed that most students had a normal BMI (50%), indicating good nutritional status. All respondents with overweight and obesity class I and II BMI demonstrated standing long jump results far below the average (100%), while only 7.1% of respondents with normal BMI reached the average category. Most respondents with normal BMI had normal hand strength (57.1%), as did those with obesity class II (83.3%). Statistical analysis using the chi-square test showed no significant relationship between BMI and muscle strength, with p-values of 0.629 and 0.792. In conclusion, most students had a normal BMI, normal handgrip strength, and low standing long jump performance. There was no significant relationship between BMI and muscle strength.

Keyword: Body Mass Index (BMI), muscle strength, medical students, obesity, handgrip strength

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INTRODUCTION

Body Mass Index (BMI) is an anthropometric index that categorizes individuals based on their height and weight. It provides an estimate of nutritional status and potential health risks and is widely applied in public health and clinical settings to define obesity and stratify the risk of associated comorbid conditions. Visceral obesity, in particular, is strongly associated with an increased risk of various pathological conditions that contribute to morbidity and mortality.

Body Mass Index (BMI) also serves as an indicator of fat and lean body mass and is commonly used in clinical practice for health risk stratification, including screening for diabetes, hypercholesterolemia, and thyroid dysfunction, as well as for providing targeted dietary and physical activity counseling.[1–7] Muscle strength is defined as the maximal force generated by a muscle against a load and is influenced by factors such as muscle cross-sectional area, fiber composition, contraction type, blood supply, and nutritional status. Decreased muscle strength has been associated with an increased risk of adverse health outcomes.[8–11] Body Mass Index (BMI) has been shown to influence muscle function, including overall muscle strength and handgrip strength. Overweight and obesity are associated with reduced muscle performance through mechanisms such as systemic inflammation and insulin resistance. Muscle strength is commonly assessed using tools such as the handgrip dynamometer and the standing long jump test. Evidence suggests that reduced muscle strength is inversely associated with excess body weight, central adiposity, and obesity-related comorbidities.[13–19]

However, findings regarding the relationship between BMI and muscle strength remain inconsistent. A cohort study conducted in the United Kingdom reported that handgrip strength increased with higher BMI but decreased in individuals with central obesity. Overweight individuals demonstrated reduced upper limb strength compared to those with a normal BMI. Conversely, individuals with a normal BMI showed greater lower limb strength but lower upper limb strength than overweight individuals. These variations may be explained by differences in muscle fiber distribution, including slow-twitch (Type I/red fibers), which are more fatigue-resistant and predominantly located in the lower fibrils for load-bearing functions, and fast-twitch (Type IIa/white fibers), which are more abundant in the upper fibrils and fatigue more quickly. Obesity may impair the activation of adenosine monophosphate-activated protein kinase (AMPK), which affects calcium signaling involved in muscle activation. Impaired AMPK activation can contribute to a shift from slow-twitch to fast-twitch muscle fibers, leading to decreased overall muscle endurance and strength.[20–24] Therefore, this study aims to investigate the relationship between BMI and muscle strength among medical students.

METHODS AND SUBJECT

Study Design

This study employed an analytical design with a cross-sectional approach, in which data were collected at a single point in time.

Population and Sampling

The study population consisted of preclinical medical students from the Faculty of Medicine, Universitas Jenderal Achmad Yani. Sample size determination was calculated using the Lemeshow formula, with $Z\alpha = 1.96$ and $Z\beta = 0.84$, and population proportions of $P1 = 0.257$ and $P2 = 0.16$. This calculation resulted in a minimum required sample size of 25.6, which was rounded to 26 participants. Sampling was conducted using a consecutive sampling technique.

Instruments and Materials

Body Mass Index (BMI) was measured using a calibrated digital scale for body weight, a microtoise for height measurement, and a calculator to determine BMI values. Muscle strength was assessed using a handgrip dynamometer.

Data Collection Procedures

Preparation: Participants were informed about the study objectives and procedures and provided written informed consent prior to participation.

Body Weight Measurement: Participants removed personal belongings and stood upright on a calibrated digital scale. Body weight was measured and recorded accurately.

Height Measurement: Participants removed accessories other than clothing and stood upright with a neutral posture. Height was measured using a microtoise from the vertex of the head to the soles of the feet.

Handgrip Strength Measurement: The handgrip dynamometer was adjusted according to the participant's hand size. Participants either sat or stood in a neutral position with the arm alongside the body, the elbow flexed at 90 degrees, and the wrist in a neutral position. Participants were instructed to perform a maximal grip for three to five seconds. The highest value obtained was recorded for analysis.

Standing Long Jump Test: Participants stood at the starting line with feet shoulder-width apart, swung their arms, and jumped forward with maximal effort. The distance from the starting line to the point of landing was measured and recorded.

Data Analysis

Data were analyzed using Statistical Product and Service Solutions (SPSS) software. Univariate analysis was conducted to describe frequency distributions of variables. Bivariate analysis was performed using the chi-square test to assess the association between BMI, handgrip strength, and standing long jump performance.

RESULTS AND DISCUSSION

Body Mass Index (BMI) Distribution

The results indicate that 50% of the students exhibited a normal BMI, whereas the remaining 50% were distributed across the categories of overweight (10.7%), obesity class I (17.9%), and obesity class II (21.4%). No participants were classified as underweight. BMI serves as an indicator of nutritional status and body composition, reflecting the balance between adipose tissue and lean mass. Accordingly, half of the respondents demonstrated a healthy nutritional profile, while the remainder fell into categories associated with an increased risk of health problems. These findings provide an overview of the nutritional distribution within this population and suggest potential implications for overall health and physical fitness.

Table 1. Frequency Distribution of BMI among Medical Students

BMI Category	Frequency (n)	Percentage (%)
Underweight	0	0
Normal	14	50.0
Overweight	3	10.7
Obesity Class I	5	17.9
Obesity Class II	6	21.4
Total	**28**	**100**

Muscle Strength Profile

The analysis showed that 67.9% of participants demonstrated normal handgrip strength, while 32.1% exhibited weak handgrip strength. No participants were classified as having strong handgrip strength. In contrast, assessment of lower limb muscle power using the standing long jump test revealed that 96.4% of participants were below average, with only 3.6% falling within the average category. These findings suggest that while most students maintain adequate upper limb grip strength, the majority exhibit markedly reduced lower limb muscle performance, which may indicate suboptimal muscular fitness in the lower extremities.

Table 2. Frequency Distribution of Muscle Strength among Medical Students

Muscle Strength Category	Frequency (n)	Percentage (%)
Handgrip Strength		
Weak	9	32.1
Normal	19	67.9
Strong	0	0
Standing Long Jump		
Above Average	0	0
Average	1	3.6
Below Average	27	96.4

Based on Table 3, the majority of Universitas Jendral Achmad Yani students with normal BMI exhibited normal handgrip strength (57.1%), while 42.9% were classified as weak. Among students in obesity class II, 83.3% had normal handgrip strength, and 16.7% were categorized as weak. Interestingly, a higher proportion of students with weak handgrip strength was observed in the normal BMI category. No measurements were obtained for the underweight category because there were no respondents in this group. The chi-square test yielded a p-value of 0.629, indicating no significant relationship between BMI and handgrip strength ($p < 0.05$). This finding suggests that factors other than BMI may influence hand muscle strength.

Table 3. Relationship between Body Mass Index (BMI) and Handgrip Strength

BMI Category	Weak (n)	Weak (%)	Strong (n)	Strong (%)	Total (n)
Underweight	0	0	0	0	0
Normal	6	42.9	8	57.1	14
Overweight	1	33.3	2	66.7	3
Obesity Class I	1	20.0	4	80.0	5
Obesity Class II	1	16.7	5	83.3	6
Total	9	32.1	19	67.9	28

Table 4. Relationship between Body Mass Index (BMI) and Lower Limb Muscle Strength (Standing Long Jump)

BMI Category	Below Average (n, %)	Average (n, %)	Total (n)
Underweight	–	–	–
Normal	13 (92.9%)	1 (7.1%)	14
Overweight	3 (100%)	0 (0%)	3
Obesity Class I	5 (100%)	0 (0%)	5
Obesity Class II	6 (100%)	0 (0%)	6
Total	27 (96.4%)	1 (3.6%)	28

Based on Table 4, the majority of respondents across all BMI categories demonstrated standing long jump performance below average. All respondents in the overweight, obesity class I, and obesity class II categories were classified as below average. Within the normal BMI category, only 7.1% of students achieved average results, while 92.9% were below average. No measurements were conducted for the underweight category due to the absence of respondents. The chi-square test produced a p-value of 0.792, indicating no significant relationship between BMI and standing long jump performance ($p < 0.05$).

Tables 3 and 4 indicate that there is no significant relationship between BMI and muscle strength (handgrip strength and standing long jump) among medical students, as evidenced by chi-square test results ($p > 0.05$). Several factors may contribute to these findings. BMI reflects the relationship between body weight and height but does not distinguish between muscle mass and fat mass. Differences in physical activity levels among students may influence muscle strength outcomes. In addition, genetic factors, diet intake, and lifestyle behaviors can affect muscle development and function. The relatively small sample size may also limit the validity of the findings.

These findings are consistent with a study by Diyan Ayu Pertiwi (2021) conducted at the Faculty of Medicine, Universitas Jenderal Soedirman, which reported no significant relationship between BMI and handgrip strength ($p = 0.260$). Similar results were reported by Setiowati (2014) in a study of basketball athletes in Semarang ($p = 0.894$). In contrast, Kadek Intan Murti Dewi (2020) at the Faculty of Medicine, Universitas Mataram, found a significant relationship between BMI and muscle strength ($p < 0.05$). A study by Al-Asadi (2018) among medical students in Iraq also reported a significant association ($p = 0.000$).[25]

CONCLUSION

The body mass index (BMI) distribution of students predominantly falls within the normal category, with additional representation in the overweight, obesity class I, and obesity class II groups. Assessment of muscle strength indicates that handgrip strength among these students is generally within normal limits. In contrast, lower limb muscle strength, as measured by the standing long jump, is largely below average. Statistical analysis revealed no significant association between BMI and muscle strength, as assessed by handgrip strength and standing long jump performance. This finding suggests that BMI may not be a primary determinant of muscular strength in this population.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest associated with the publication of this article.

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