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Body Mass Index and Muscle Strength in Older Adults: A Cross-Sectional Study

Riswana[1*], Ita Rini[2], Djohan Aras[3], Yonathan Ramba[4], Yery Mustari[5], Ummulkhairiyah Ikhlasun Lum[6], Citra Aulia Alwi[7], Rizta Tempo[8], Nurul Fadhilah Haris[9], Salma Nur Madina[10]

[1-10]Hasanuddin University, Makassar, South Sulawesi, Indonesia

*Corresponding author:
E-mail: riswanarandy.07@gmail.com

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Abstract

Introduction: Declines in muscle mass and strength are major contributors to reduced functional capacity and quality of life among older adults. Body mass index (BMI) is often used as a proxy for body composition; however, its association with muscle strength remains unclear. This study aimed to examine the relationship between BMI and muscle strength, specifically handgrip and lower limb strength, in community-dwelling older adults.

Methods: A cross-sectional study was conducted from December 2023 to February 2024 at Tamalanrea Community Health Center, Makassar. Ninety older adults were recruited through purposive sampling according to predefined inclusion criteria. BMI was calculated using measurements obtained with a digital scale and microtoise. Handgrip strength was measured with a handgrip dynamometer, while lower limb strength was assessed using the 30-Second Chair Stand Test. Statistical analysis was performed using Somers' d correlation test.

Results: There was no significant correlation between BMI and handgrip strength ($p = 0.941$, $r = 0.006$), nor between BMI and lower limb strength ($p = 0.476$, $r = 0.049$). These results indicate that BMI status—whether within normal or abnormal ranges—does not significantly influence muscle strength in older adults.

Conclusion: BMI alone may not be a reliable indicator of muscle strength in older adults. Other factors such as muscle composition, physical activity, and nutritional status may play more critical roles in determining functional capacity.

Keywords

Older adults, Body mass index, Muscle strength, Handgrip, Lower extremity, Cross-sectional study

Introduction

According to the World Health Organization (WHO), the global elderly population is projected to double to 2.1 billion by 2050, with the number of people aged 80 and above expected to triple between 2020 and 2050, reaching approximately 462 million.[1] Aging is associated with changes in body composition, including increased fat mass and reduced fat-free mass and skeletal muscle.[2] In older adults, body composition—as reflected by body mass index (BMI)—can change due to physiological factors, nutritional intake, decreased physical activity, and socioeconomic status.[3]

These changes in body composition provide a physiological rationale for why BMI may not fully reflect muscle mass in the elderly. Individuals with either undernutrition or overnutrition tend to have reduced muscle strength, especially in later life, due to progressive declines in physiological function.[4] A significant reduction in BMI, particularly due to decreased muscle mass, is considered one of the key factors contributing to diminished functional capacity and activity levels in older adults, ultimately impacting their quality of life.[5]

Research examining the relationship between BMI and both handgrip and lower limb muscle strength remains scarce, with limited and inconclusive evidence. Further investigation is therefore needed. A study by Amin et al. recommended future research with larger sample sizes, as their study only included 16 participants. Their findings indicated a positive correlation between nutritional status—as measured by BMI—and upper and lower limb muscle strength.[6]

Handgrip and lower limb strength are important indicators of overall muscle quality in older adults. Handgrip strength (HGS) is commonly used as a screening tool to assess muscle function and overall physical capability. It has been widely utilized to predict mortality and functional decline in the elderly.[7] Similarly, lower limb strength is a critical component of physical performance, playing an essential role in weight-bearing activities and daily functions such as walking and standing—particularly related to mobility in older adults. [8,9] Declining muscle strength in aging is associated with serious consequences, including chronic diseases, loss of independence, and increased risk of mortality.[10]

A study by Dewi involving 77 elderly individuals in Jember—most aged 60–69 years—found a high risk of malnutrition due to diminished digestive function, inefficient metabolism, nutrient deficiencies, and homeostatic imbalance.[8] In addition to the risk of malnutrition, older adults are also highly susceptible to obesity. A study by Gustiranda and Septiana reported that among those aged 60–74 years, the prevalence of obesity was 63.3%, whereas only 36.7% had normal BMI.[9]

A preliminary observation conducted by the researchers on December 21, 2023, at the Tamalanrea Community Health Center in Makassar identified 112 individuals aged 60 years and older. A pilot assessment was conducted with 12 elderly participants, most of whom were no longer employed. The researcher measured BMI, handgrip strength, and lower limb strength. The results showed varying BMI levels, with the majority categorized as overweight.

Handgrip strength was measured using a handgrip dynamometer, while lower limb strength was assessed with the 30-Second Chair Stand Test. Of the 12 participants, five had weak handgrip strength, seven had weak lower limb strength, three had weakness in both, and three had normal strength in both areas. No prior physiotherapy-related studies had been conducted at the Tamalanrea Community Health Center. These findings highlight the need for early screening and appropriate physiotherapy interventions in the elderly population. Based on these observations, the present study aims to examine whether there is an association between BMI and both handgrip and lower limb muscle strength in older adults at the Tamalanrea Community Health Center, Makassar.

Methods

This study was conducted at the Tamalanrea Community Health Center, Makassar, from December 2023 to February 2024. It employed a quantitative, descriptive-analytical approach using a cross-sectional study design. A total of 90 participants were selected using purposive sampling, taking into account the target population size (112 individuals), a 5% significance level, and potential dropouts.

The independent variable in this study was body mass index (BMI), calculated as body weight in kilograms divided by height in meters squared (kg/m²). The dependent variables included handgrip strength, measured using a handgrip dynamometer in kilograms (kg), and lower limb muscle strength, assessed using the 30-Second Chair Stand Test, which records the number of full sit-to-stand repetitions performed within 30 seconds.

The inclusion criteria were adults aged ≥60 years, cooperative, willing to participate, and without physical disabilities or impairments that could affect mobility. The exclusion criteria included elderly individuals with hearing impairments, those undergoing special medical care (bed rest), or those unable to complete the assessments.

The instruments used included a calibrated digital weighing scale, a microtoise, a handgrip dynamometer, and the standardized procedure for the 30-Second Chair Stand Test. All measurements were performed by trained physiotherapists following the standardized measurement protocol from the Centers for Disease Control and Prevention. To minimize measurement bias, all assessments were conducted by the same team using calibrated instruments. Each measurement was repeated three times, and all tests were administered at the same time of day to reduce diurnal variation in muscle strength.

Data analysis consisted of univariate analysis for frequency and descriptive distribution, followed by bivariate analysis using Somers' d test to assess the strength and direction of the relationship between BMI and both handgrip and lower limb strength, with a significance level set at $p \leq 0.05$. Normality testing was performed prior to the bivariate analysis. Data processing was carried out using SPSS software. No data were missing in this study. Informed consent was obtained from all participants. Confidentiality, anonymity, and ethical considerations were maintained throughout the study.

Results

This study involved 90 older adults out of a total population of 112 elderly individuals registered at the Tamalanrea Community Health Center in Makassar. During the data collection period, only 90 participants were available for direct contact and all agreed to participate in the study. All participants met the established inclusion criteria. There were no missing data for any of the variables. Several potential confounding variables may have influenced BMI, handgrip strength, and lower limb strength among the elderly, including age, sex, genetics, environment, physical activity, and limb length.

Table 1. General characteristics of respondents

Characteristic	Frequency (n)	Percentage (%)
Age		
- Elderly (60–74 years)	84	93.3
- Old (75–80 years)	6	6.7
Sex		
- Male	38	42.2
- Female	52	57.8
Occupation		
- Laborer	1	1.1
- Lecturer	1	1.1
- Motorcycle Driver	1	1.1
- Teacher	1	1.1
- Farmer	6	6.7
- Security	1	1.1
- Parking Attendant	1	1.1
- Entrepreneur	5	5.6
- Unemployed	73	81.1

Table 1 illustrates the distribution of respondents by age, sex, and occupation. The majority were categorized as "elderly" (60–74 years), accounting for 93.3% of participants. Most respondents were female (57.8%). A substantial portion of the elderly participants were unemployed (81.1%).

Table 2. Body Mass Index distribution

BMI Category	Frequency (n)	Percentage (%)
Severely underweight	3	3.3
Underweight	5	5.6
Normal	46	51.1
Overweight	18	20.0
Obese	18	20.0

Table 2 presents the distribution of BMI among older adults categorized based on the Ministry of Health guidelines: severely underweight (<17 kg/m²), underweight (17–18.5 kg/m²), normal (18.5–25 kg/m²), overweight (25–27 kg/m²), and obese (>27 kg/m²). The majority of respondents had a normal BMI (51.1%), indicating a relatively good nutritional status.

Table 3. BMI by sex, age group, and occupation

Characteristics	Severely Underweight (%)	Underweight (%)	Normal (%)	Overweight (%)	Obese (%)	Total (%)
Gender						
Male	0 (0.0)	2 (2.2)	18 (20.0)	10 (11.1)	8 (8.9)	38 (42.2)
Female	3 (3.3)	3 (3.3)	28 (31.1)	8 (8.9)	10 (11.1)	52 (57.8)
Total	3 (3.3)	5 (5.6)	46 (51.1)	18 (20.0)	18 (20.0)	90 (100)
Age						
Elderly	1 (1.1)	5 (5.6)	43 (47.8)	17 (18.9)	18 (20.0)	84 (93.3)
Old	2 (2.2)	0 (0.0)	3 (3.3)	1 (1.1)	0 (0.0)	6 (6.7)
Total	3 (3.3)	5 (5.6)	46 (51.1)	18 (20.0)	18 (20.0)	90 (100)
Occupation						
Laborer	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)	1 (1.1)
Lecturer	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)	1 (1.1)
Motorcycle Driver	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)	1 (1.1)
Farmer/Teacher	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)	1 (1.1)
Others	0 (0.0)	1 (1.1)	3 (3.3)	2 (2.2)	0 (0.0)	6 (6.7)
Security	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)	1 (1.1)
Parking Attendant	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)
Entrepreneur	0 (0.0)	0 (0.0)	3 (3.3)	0 (0.0)	2 (2.2)	5 (5.6)
Unemployed	3 (3.3)	3 (3.3)	36 (40.0)	16 (17.8)	15 (16.7)	73 (81.1)
Total	3 (3.3)	5 (5.6)	46 (51.1)	18 (20.0)	18 (20.0)	90 (100)

BMI was predominantly normal among female respondents (31.1%), in line with the higher female participation. In terms of age, all BMI categories (underweight, normal, overweight, and obese) were mainly represented by the elderly group (60–74 years).

Table 4. Handgrip strength by sex, age group, and occupation

Characteristic	Weak (%)	Normal (%)	Strong (%)	Total (%)
Sex				
- Male	17.8	55.3	1.1	42.2
- Female	43.3	13.3	1.1	57.8
Age Group				
- Elderly	56.7	34.4	2.2	93.3
- Old	4.4	2.2	0.0	6.7

Classification of handgrip strength was based on age and sex standards. Weak handgrip strength was more prevalent among females (43.3%), while normal handgrip strength was dominant among males (55.3%). The elderly group dominated all strength categories.

Table 5. Lower limb strength by sex, age group, and occupation

Characteristic	Weak (%)	Normal (%)	Total (%)
Sex			
- Male	28.9	13.3	42.2
- Female	53.3	4.4	57.8
Age Group			
- Elderly	75.6	17.8	93.3
- Old	6.7	0.0	6.7

Lower limb strength classifications followed CDC criteria. Weakness was more prevalent among females (53.3%), while normal strength was more common in males (13.3%). The elderly group (60–74 years) showed the highest prevalence in both strength categories.

Table 6. Somers' d correlation between BMI and handgrip strength

Variable	n	p-value	r
BMI vs. Handgrip Strength	90	0.941	0.006

Table 6 shows that there was no significant association between BMI and handgrip strength (p = 0.941). The correlation coefficient (r = 0.006) indicates a negligible correlation.

Table 7. Somers' d correlation between BMI and lower limb strength

Variable	n	p-value	r
BMI vs. Lower Limb Strength	90	0.476	0.049

Table 7 also demonstrates no significant correlation between BMI and lower limb strength (p = 0.476), with a very weak correlation coefficient (r = 0.049). These findings suggest that BMI status, whether normal or abnormal, is not significantly associated with muscle strength (handgrip or lower limb) in older adults.

Discussion

This study demonstrated no significant relationship between Body Mass Index (BMI) and handgrip or lower limb muscle strength among older adults attending Tamalanrea Primary Healthcare Center in Makassar. Based on BMI distribution, the majority of older adults fell into the normal BMI category (51.1%). Nevertheless, the proportion of those classified as overweight or obese was substantial, totaling 40%, with each group comprising 20%. These findings are consistent with the results reported by Malo et al., who noted that individuals aged 60 years and older are particularly susceptible to obesity due to declining physiological function, which affects the body's ability to absorb fat for energy production.[10] This accumulation of fat tissue is primarily driven by reduced physical activity, which causes excess energy to be stored in adipocytes, thereby promoting pathological characteristics of obesity through hypertrophy and altered nutritional signaling.[11] However, these findings should be interpreted cautiously, as several confounding variables were not controlled for in the analysis.

Handgrip strength in this study was measured using a handgrip dynamometer. The results showed that 61.1% of the 90 older adults had weak handgrip strength. This aligns with the study by Yusufirashim et al., in which 94.7% of 57 respondents exhibited poor handgrip strength, attributed to factors such as age, nutritional intake, and education level.[12] In our sample, weak handgrip strength was predominantly observed among female participants (43.3%). This can be explained by differences in body composition, as men generally possess less body fat and higher muscle mass than women, resulting in greater muscle strength.[13]

Lower limb strength in this study was assessed using the 30-Second Chair Stand Test. Results indicated that 82.22% of participants exhibited weak lower limb strength. This is consistent with findings by Lintin and Miranti, who reported a higher rate of decline in type II muscle fibers (57%) compared to type I fibers (25%) in older adults.[14] Type I fibers are responsible for short, strong contractions, whereas type II fibers are involved in oxidative metabolism through aerobic processes. In this study, weak lower limb strength was also more prevalent among females (53.3%). According to Juntara, higher levels of testosterone in men contribute to greater muscle development, which supports superior strength outcomes.[13] The reduction in muscle contraction capability may be attributed to a lack of physical activity, which directly impacts satellite cell activation—the key precursor for muscle regeneration.[15]

The Somers'd test indicated no significant relationship between BMI and handgrip strength (p = 0.941, r = 0.006). Most participants demonstrated poor handgrip strength regardless of whether their BMI was within normal or abnormal ranges. These findings corroborate those of Fitriani and Purwaningtyas, who observed poor handgrip strength among nearly half of their 164 respondents.[16] Aging contributes to morphological changes in skeletal muscle, particularly within mitochondria. Older adults exhibit mitochondria that appear larger and rounder compared to those in younger individuals. These structural changes lead to reduced mitochondrial content, which impairs mitochondrial metabolism, protein synthesis, and ultimately contributes to muscle strength decline in aging individuals.[17] Furthermore, Ramsey et al. emphasized the role of physical activity intensity in preserving muscle strength, noting that reduced protein synthesis rates due to inactivity negatively affect muscle quality and function.[18]

Similarly, no significant relationship was found between BMI and lower limb muscle strength (p = 0.476, r = 0.049). Of the 90 participants, 82.2% (n = 74) exhibited lower limb weakness, which was observed across both normal (42.2%) and abnormal (57.8%) BMI groups. This widespread muscle weakness can be attributed to age-related physiological changes, including mitochondrial morphological alterations and decreased protein synthesis resulting from insufficient physical activity.[19] The urban setting of the study, characterized by accessible infrastructure, transportation, and digital technology, may also contribute to reduced daily physical activity among older adults. Continuous physical activity is essential for enhancing muscle strength, as it stimulates muscle contraction adaptation, leading to increased contractile protein synthesis and growth of actin-myosin filaments in the myofibrils.[20]

This study is limited to older adults residing in an urban area (Tamalanrea Primary Healthcare Center, Makassar), which restricts the generalizability of findings to rural populations or regions with different demographic characteristics. Additional limitations include the cross-sectional design, which does not support causal inference, purposive (non-random) sampling, and the absence of control for confounding variables such as physical activity level, nutritional status, and comorbidities. These findings highlight the importance of routine evaluation of BMI and muscle strength among older adults. Preventive interventions, including elderly exercise programs, resistance training, and nutritional education, should be prioritized to counteract the decline in muscle strength that may compromise quality of life in the aging population.

Conclusion

This study found that the elderly at Tamalanrea Public Health Center in Makassar were predominantly classified as having a normal Body Mass Index (BMI) (51.1%). However, nearly half exhibited abnormal BMI, particularly in the overweight and obese categories (20% each). Among females, the normal and obese categories were more common, while overweight status was more prevalent among males. Most participants had weak handgrip strength (61.1%) and lower limb strength (82.2%), predominantly observed among non-working elderly females. There was no significant relationship between BMI and either handgrip or lower limb muscle strength, with correlation levels considered very weak.

Health centers are encouraged to promote balanced nutrition and moderate-intensity exercise (e.g., 150 minutes of walking per week) among overweight and obese elderly. This study may serve as a reference for developing

elderly programs aimed at improving muscle strength and quality of life. Suggested interventions include elderly exercise routines and Otago exercises to prevent fall risks associated with muscle weakness. Future researchers should assess physical activity levels and explore additional factors influencing muscle strength in older adults.

Author Contribution

Riswana: Conceptualization, methodology, data collection, data analysis, and manuscript drafting.
Ita Rini: Supervision, data interpretation, and critical revision of the manuscript.
Djohan Aras: Validation, resources, and review of the final draft.
Yonathan Ramba: Data collection, project administration, and technical support.
Yery Mustari: Statistical analysis, data interpretation, and editing.
Ummulkhairiyah Ikhlasun Lum: Literature review, data acquisition, and manuscript preparation.
Citra Aulia Alwi: Data curation, visualization, and assistance with methodology.
Rizta Tempo: Field coordination, participant recruitment, and data collection.
Nurul Fadhilah Haris: Data entry, formal analysis, and drafting support.
Salma Nur Madina: Documentation, formatting, and proofreading of the final manuscript.
All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this study.

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Ethics Statement

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Nursing, Hasanuddin University (Approval No. 671/UN4.18.3/TP.01.02/2024). All participants provided informed consent prior to data collection.

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