The Muscle Mass and Related Factors of Patients with Hip Fractures at Assiut University Trauma Hospital: A Cross-sectional Analytic Study

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Abstract:
Introduction: This study investigated the correlation between muscle mass and the factors influencing muscle mass.

Patients and Methods: A cross-sectional analytic study included 90 hip-fractured patients. This study comprised of patients admitted throughout the specified time frame from November 2021 to September 2023 to the Trauma Hospital, Assiut University Hospital. The collected data included a personal interview questionnaire, including socio-demographic data, clinical data, special and nutritional habits, and an assessment of muscle mass in the hip-fractured patients by a bioelectrical impedance analysis (BIA) device.

Results: Skeletal muscle mass shows a significant positive correlation with body weight, height, BMI, BMR, total body water, and protein. Other correlations were statistically not significant. No significant difference in skeletal muscle mass was observed among elderly patients with fractures and varying food habits. Male patients exhibited significantly greater skeletal muscle mass than female patients, and individuals with a higher BMI demonstrated larger skeletal muscle mass than those with a lower BMI.

Conclusion: Muscle mass is affected by weight, height, BMI, BMR, total body water, and protein.

Keywords: Muscle mass; Hip fracture patients; Associated factors.

Introduction:

An individual adult's total body skeletal muscle mass (SMM) is determined by several factors, including their size (i.e., height) (1), level of adiposity (2), and nutrition(3).

As a result, age-related alterations in skeletal muscle are linked to unfavorable consequences such as pathological bone fractures and even mortality (4).

There is no available research about muscle mass and its related factors in our location.

Patients and Methods

Study Design: Analytic, cross-sectional study

Study Site: Orthopedic department at Trauma Hospital at Assiut University Hospitals (AUHs). This study was carried out between November 2021 and September 2023.

Study Participants: The study included old patients with hip fractures who had been admitted to the Trauma Hospital at Assiut University Hospitals.

Inclusion Criteria: aged patients > 50 years with hip fracture.

Exclusion Criteria: patients with dementia, neurological conditions, muscle disease, and patients > 80 years, as at this age, they are not cooperative in answering the questionnaire.

Sample Size Calculation: The sample size for this study was calculated using Epi Info™ software (version 7). The calculation was based on an annual population of 200 hip fracture patients at the trauma hospital,

with a confidence level of 95% and statistical power of 80%. These parameters were input into the software's sample size calculation module, which employs a standard formula for population surveys. The sample size for the study was determined to be 90 patients.

Ethical Considerations:

The study followed the guidelines by Assiut University's Ethical Committee and was approved by the committee with an approval number (IRB No. 17101579). ***Clinical trial registration:*** NCT05141981. Registered September 2021.

Data Collection:

After admission of the patients and during the preparation for the hip fracture operation, a semi-structured questionnaire was used to collect data from every patient. The aim of the study and the way of filling out the questionnaire were explained to each patient and relative, and approval from the patient was obtained.

The collected data included:

A-The questionnaire was divided into three sections:

A semi-structured questionnaire was used; it was applied through personal interviews with each patient and their caregiver; the researcher was the interviewer; and the questionnaire was divided into the following sections:

The first section included the patients' demographic data, such as age, sex, residence, name, and ID number.

The second section contains questions about history, such as chronic diseases, previous surgeries, previous fractures, previous medication, or previous hospitalization.

The third section included questions about special habits such as smoking, coffee, soda, or tea drinking, milk, cheese, or yogurt eating.

B-Investigation:

1- Inbody device test: The patient was transported to the rehabilitation room in the trauma unit to have an in-body test on the second day following hip fracture surgery. This timing was chosen as it appeared to be an appropriate period after receiving physiotherapy. During the initial 10 days, the patient's muscle mass remained stable, but subsequently declined (5).

2- Anthropometric measurement: Weight, height, and BMI were estimated according to a study by Courtney M Peterson et al. (6).

- BMI is classified as follows: those with a BMI less than 18.5 are considered underweight; those with a BMI between 18.5 and 24.9 are considered to have a normal healthy weight; individuals with a BMI between 25.0 and 29.9 are considered overweight; and those with a BMI of 30.0 or more are classified as obese.

Statistical Analysis:

The statistical computations were performed using SPSS (Statistical Package for the Social Sciences; SPSS Inc., Chicago, IL, USA) version 22. The data were analyzed using statistical measures such as the mean ± standard deviation (±SD) for normally distributed data or the median and range for non-normally distributed data. Frequencies (number of cases) and relative frequencies (percentages) were used when suitable. Quantitative variables were compared using a t-test and an ANOVA test for data that followed a normal distribution and the Mann-Whitney U test for data that did not follow a normal distribution. The Pearson correlation test was used to analyze the correlation between different variables. The p-value has been determined to be statistically significant at the 0.05 level.

Results:

The study comprised 90 patients with various hip fractures. The baseline data of the analyzed individuals is described in Table 1, with a mean age of 66.79 ± 8.05 years and a range of 50 to 80 years old. 47.8% were males, and 19 cases (21.1%) were smokers.

The mean weight of the examined cases was 68.15 ± 14.57 kg (range: 36.9 to 95.3 kg), the mean height was 163.73 ± 7.88 cm2 (range: 150 to 187 cm2), and the mean BMI was 25.60 ± 6.00 kg/m2 (range: 13.6 to 37.6 kg/m2), and they were categorized as follows: 10.0%, 40.0%, 22.2%, and 27.8%

were underweight, normal weight, overweight, and obese, respectively. For related comorbidities, 25.6% were diabetic, and 36.7% were hypertensive.

Table 1: Baseline data of the studied participants at Trauma Hospital, Assiut University (2021-2023).

Baseline data	Total cases (n=90)
Age (years)	
- Mean ± SD	66.79 ± 8.05
- Median (range)	66 (50 – 80)
Sex, n (%)	
- Male	43 (47.8%)
- Female	47 (52.2%)
Smokers, n (%)	19 (21.1%)
Weight (kg)	
- Mean ± SD	68.15 ± 14.57
- Median (range)	69.7 (36.9 – 95.3)
Height (cm2)	
- Mean ± SD	163.73 ± 7.88
- Median (range)	163 (150 – 187)
BMI (kg/m2)	
- Mean ± SD	25.60 ± 6.00
- Median (range)	25.1 (13.6 – 37.6)
- Underweight <18.5	9 (10.0%)
- Normal weight 18.5-24.9	36 (40.0%)
- Overweight 25-29.9	20 (22.2%)
- Obese ≥ 30	25 (27.8%)
Fracture type, n (%)	
- Trochanteric fracture	54 (60.0%)
- Neck of femur	36 (40.0%)
Associated comorbidities, n (%)	
- Diabetes	23 (25.6%)
- Hypertension	33 (36.7%)

BMI: body mass index. The data, presented as mean ± standard deviation (SD), median (range), or number (percentage) as appropriate

In Table 2, the correlation analysis revealed significant positive associations between skeletal muscle mass (SMM) and several anthropometric and body composition parameters. Specifically, SMM showed strong correlations with body weight ($r = 0.563$, $p < 0.001$), height ($r = 0.594$, $p < 0.001$), and BMI ($r = 0.291$, $p < 0.001$). Additionally, SMM demonstrated robust relationships with basal metabolic rate (BMR) ($r = 0.904$, $p < 0.001$), total body water ($r = 0.871$, $p < 0.001$), and protein content ($r = 0.938$, $p < 0.001$). These findings suggest that SMM is closely linked to overall body composition and metabolic factors. The strong correlation between SMM and BMR is particularly noteworthy, as it aligns with the understanding that individuals with higher lean body mass tend to have higher basal metabolic rates. It's important to note that other variables assessed in the study did not show statistically significant correlations with SMM ($p > 0.05$), indicating that the relationships observed are specific to the aforementioned parameters.

Table 2: Correlation analysis between skeletal muscle mass and subject characteristics among the studied group at Trauma Hospital Assuit University (2021-2023).

Variables	SMM
Age	
- R	-0.113
- P	0.287
Weight	
- R	0.563
- P	<0.001
Height	
- R	0.594
- P	<0.001
BMI	
- R	0.291
- P	0.005
Fat mass	
- R	0.066
- P	0.539
BMR	
- R	0.904
- P	<0.001
Total water	
- R	0.871
- P	<0.001
Protein	
- R	0.938
- P	<0.001

SMM: skeletal muscle mass; **BMR:** basal metabolic rate. ***** Significance defined by $p < 0.05$, r = correlation coefficient

Table 3 analyzes patient characteristics and nutritional habits in relation to SMM in elderly fractured patients and reveals notable findings. The study failed to detect significant differences in SMM across participants with varying dietary habits ($P > 0.05$), suggesting that nutritional patterns may not be a primary determinant of muscle mass in this population. However, gender and BMI emerged as significant influences on SMM. Male patients exhibited substantially higher SMM than female patients ($P < 0.001$), consistent with established physiological gender differences. These results highlight the complex interplay of factors affecting SMM in elderly fractured patients, with gender dimorphism and body composition playing prominent roles, while the impact of dietary habits appears less pronounced in this cohort.

Table 3: The relations between skeletal muscle mass and different patients' characteristics and nutrition habits among the studied group at Trauma Hospital Assuit University (2021-2023).

Subgroup		n	SMM		P value
			Mean ± SD	Median (range)	
Age	< 60 years	14	23.52 ± 4.50	24.5 (13.3 - 31.4)	0.178
	≥ 60 years	79	21.40 ± 5.51	21.2 (13.4 - 46.1)	
Gender	Male	43	24.40 ± 4.04	24.4 (16.0 - 33.6)	**<0.001**
	Female	47	19.29 ± 5.37	18.8 (13.3 - 46.1)	
BMI	Underweight	9	15.82 ± 2.31	16.0 (13.4 - 19.8)	**<0.001**
	Normal weight	36	21.11 ± 4.45	21.8 (13.3 - 29.6)	
	Overweight	20	24.47 ± 7.52	23.9 (14.9 - 46.1)	
	Obese	25	22.55 ± 3.49	22.7 (14.3 - 30.2)	
Steroid intake	No	86	21.80 ± 5.40	21.4 (13.3 - 46.1)	0.755
	Yes	4	20.18 ± 5.89	20.7 (13.7 - 25.6)	
Smoking	No	71	21.39 ± 5.72	20.5 (13.3 - 46.1)	0.258
	Yes	19	22.98 ± 3.89	24.4 (16.0 - 30.2)	
Diabetes	No	67	21.91 ± 5.63	22.1 (13.3 - 46.1)	0.583
	Yes	23	21.19 ± 4.74	20.3 (13.5 - 33.6)	
Hypertension	No	57	21.83 ± 4.57	21.7 (13.3 - 32.2)	0.817
	Yes	33	21.55 ± 6.67	20.3 (13.6 - 46.1)	
SARC-F (total score)	Normal	79	22.07 ± 5.30	22.1 (13.3 - 46.1)	0.113
	Abnormal	11	19.31 ± 5.75	18.8 (13.4 - 31.4)	
Coffee	No	84	21.85 ± 5.48	21.6 (13.4 - 46.1)	0.443
	Yes	6	20.08 ± 4.25	20.0 (13.3 - 24.7)	
Tea	No	17	19.65 ± 4.87	18.8 (13.4 - 30.2)	0.067
	Yes	73	22.21 ± 5.43	22.2 (13.3 - 46.1)	
Soda	No	72	21.68 ± 5.67	20.5 (13.4 - 46.1)	0.862
	Yes	18	21.93 ± 4.28	22.4 (13.3 - 27.0)	
Milk	No	68	21.71 ± 5.43	21.4 (13.3 - 46.1)	0.947
	Yes	22	21.80 ± 5.43	21.9 (13.4 - 33.6)	
Cheese	No	67	22.08 ± 5.41	21.4 (13.3 - 46.1)	0.290
	Yes	23	20.70 ± 5.37	21.4 (13.4 - 33.6)	
Yogurt	No	79	21.89 ± 5.30	21.4 (13.3 - 46.1)	0.441
	Yes	11	20.55 ± 6.23	20.3 (13.4 - 33.6)	

BMI: body mass index. Data are stated as mean ± SD, median (range). Significance denoted by P-value ≤ 0.05.

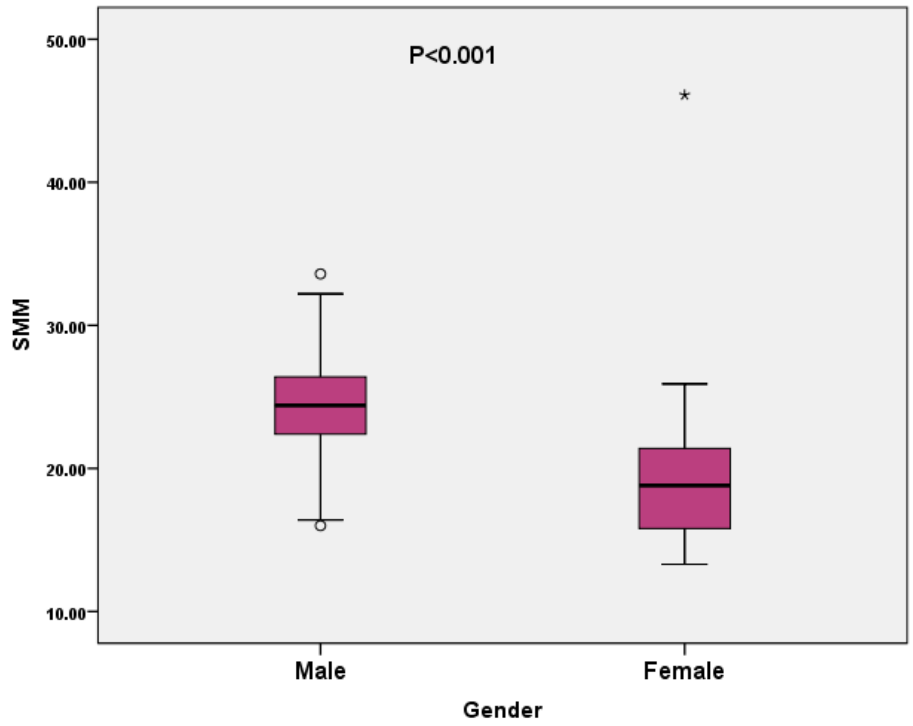

Figure 1: Box plot graph showing the difference in SMM according to gender distribution among the studied participants

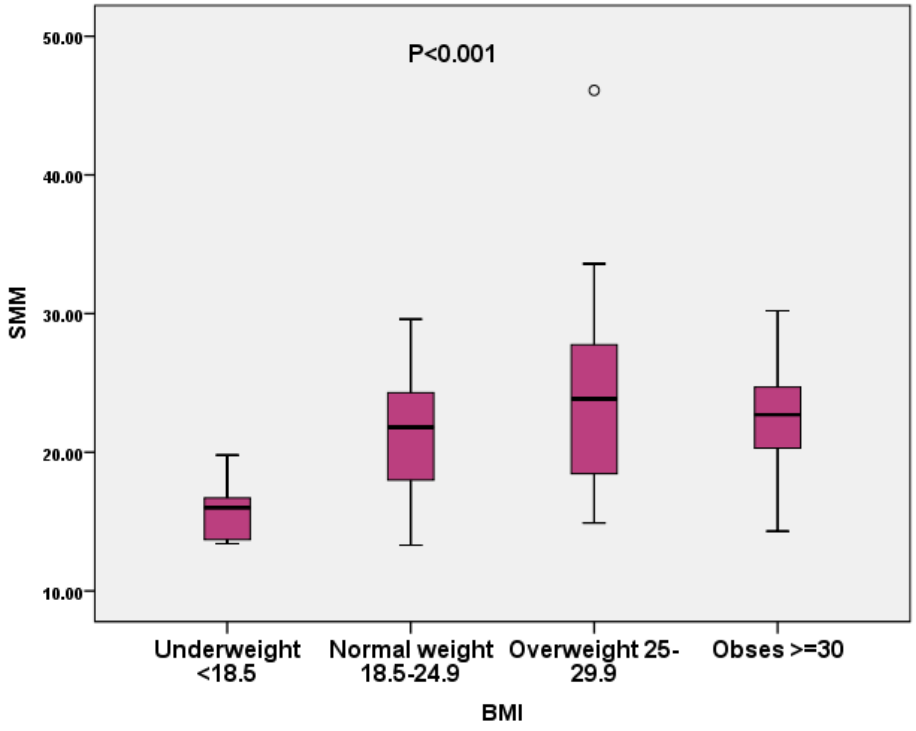

Figure 2: Box plot graph showing the difference in SMM according to BMI distribution among the studied participants

Discussion

Skeletal muscle mass (SMM) and basal metabolic rate

The current study found an association between BMR and SMM. Z. Maghbooli and S. Mozaffari conducted a study in Iran that corroborates these findings, demonstrating that a lower BMR is associated with an increased risk of reduced SMM in participants. This study also identified a significant correlation between bone density,

muscle mass, and BMR. After accounting for obesity, lower BMR was the only factor significantly associated with lower muscle mass and bone density in the lumbar and hip sites. These results suggest that BMR is crucial in maintaining muscle mass and bone density, highlighting its potential as an early predictor for osteoporosis and sarcopenia (7).

While most studies support the association between BMR and SMM, some research provides different perspectives. For instance, using several CGA parameters, a study on older males evaluated the association between BMR and frailty and low SMM. This study assessed the predictive ability of BMR parameters for detecting low SMM, frailty, and CGA status. The findings indicated that BMR could serve as an objective marker for sarcopenia and frailty in older males, suggesting that patients with lower BMR should be screened for these conditions. This highlights the variability in the relationship between BMR and SMM, emphasizing the need for further research to understand the underlying mechanisms and potential clinical applications (8).

SMM and body composition

The current study found a significant association between low SMM and individuals with low levels of water, protein, and minerals in their body composition. Deficiency in dietary protein can lead to muscle wasting and low SMM, while adequate hydration is essential for maintaining muscle mass, as dehydration can also contribute to muscle wasting. Many studies support this theory. For instance, a study evaluating the relationship between the extracellular water-to-total body water ratio (ECW/TBW) and low SMM found that a higher ECW/TBW ratio is associated with an increased risk of low SMM, suggesting that this ratio could serve as a useful marker for identifying individuals at risk of sarcopenia(9).

However, some studies suggest that low water, protein, and mineral levels in body composition tests can contribute to low SMM, but they are not the only factors. For example, a study on patients with chronic kidney disease (CKD) and end-stage renal disease (ESRD) found that muscle wasting and cachexia contribute to frailty and morbidity but did not directly link these conditions to low levels of water, protein, and minerals in their body composition tests (10).

Body mass index (BMI):

The correlation between BMI and skeletal muscle mass

An observational study on 141,451 Chinese adults found a positive correlation between BMI and SMM, indicating that higher BMI is associated with greater muscle mass (11).

However, other studies provide contrasting perspectives. For instance, a study published in BMC Public Health found that higher self-esteem was associated with a higher BMI in normal-weight individuals but a lower BMI in obese class II and III individuals (12).

Nutritional factors

a. Coffee and Tea Consumption:

A study investigating the correlation between coffee and tea consumption and cause-specific mortality found no clear association between these beverages and low SMM (13).

However, other studies have shown a relationship between coffee and tea consumption and SMM. For example, one study found that light coffee consumption is protective against decreasing SMM, whereas frequent coffee consumption is associated with obesity in Korean adults (14). These findings suggest that while moderate coffee consumption may have protective effects on muscle mass, excessive consumption could be linked to adverse outcomes such as obesity.

b. Milk, Cheese, and Yogurt Consumption:

A study on dairy consumption and CVD found no clear association between dairy consumption and SMM (15).

However, other studies showed an association between cheese, milk, and yogurt ingestion and SMM. A study

reported that men who consumed milk at least once daily had a significantly lower risk of developing low SMM due to their reduced risk of developing a low SMI (16).

Chronic diseases:

a. Diabetes:

In a study about the association between Diabetes and low SMM, they found no association between the duration or control of Diabetes and low SMM (17).

However, other studies have shown an association between Diabetes and SMM. For instance, a meta-analysis found that high HbA1c levels, prediabetes, diabetes, and diabetes complications were associated with an increased risk of low SMM (18).

b. Hypertension:

A study investigating low SMM and its adverse outcomes in an elderly population with coronary artery disease (CAD) found no significant association between hypertension and low SMM (19).

However, other studies have demonstrated a connection between hypertension and SMM. For instance, a systematic review and meta-analysis revealed that low SMM was associated with hypertension (20).

Cigarette smoking:

The following studies suggest that while smoking may have some association with low SMM, the relationship is not straightforward, and further research is needed to understand it fully. A meta-analysis concluded that cigarette smoking could have relatively little impact on the development of low SMM (21).

However, some studies suggest smoking increases the risk of low SMM. A study reported that men who consumed milk at least once daily had a significantly lower risk of developing a low SMM due to their reduced risk of developing a low SMI (22).

Study strengths:

We used a validated tool, the InBody device, to measure body composition and muscle mass. This device is a non-invasive, quick, and accurate tool for assessing body composition and muscle mass, making it an ideal choice for our study. The InBody device utilizes bioelectrical impedance analysis (BIA) to provide detailed metrics, including fat mass, muscle mass, and body water, which are crucial for understanding individuals' overall health and fitness.

Study limitations:

In this study, we encountered some limitations and difficulties, such as:

The measurement of SMM using the bioelectrical impedance device (BIA) was challenging for the patients with hip fractures, who had difficulty standing on the device.

Conclusion:

The patient's weight, height, BMI, fat mass, BMR, total water, protein, and minerals are significantly related to SMM. A correlation test confirms this.

Comparing the baseline data between patients with and without low SMM, it was observed that age, sex, smoking status, fracture type, steroid administration, and the presence of associated other comorbidities showed no significant difference. However, patients' weight, height, and BMI were significantly lower among lower SMM cases.

Recommendations and future work:

We recommend further studies on skeletal muscle mass and its associated factors in hip fracture patients to optimize patient care and minimize complications.

List of abbreviations:

SMM: skeletal muscle mass, BMR: basal metabolic rate, SMI: skeletal muscle index,

Ethical approval and consent to participate:

The study adhered to Assiut University's Ethical Committee regulations and was approved by the committee with an approval number (IRB No. 17101579). Informed consent was obtained from the participants, including the study's objectives, benefits, and confidentiality.

Consent for publications:

Not applicable.

Availability of data and materials:

The data sets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

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Authors' contributions:

The authors (Abdelhafeez H. Abdelhafeez, Dalia G. Mahran, and Osama A. Farouk) contributed equally to the study. All authors have read and agreed to the submitted version of the manuscript.

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