

Gender and Body Mass Index Association with Skeletal Muscle Work Output in Young Adults: A Cross-Sectional Study Using Mosso's Ergograph

Priyanka Mourya, Milind Chitale

ABSTRACT

Background: Skeletal muscle performance plays a key role in sustaining physical activity and is influenced by factors such as gender and body composition. While males typically demonstrate higher muscle strength, the impact of body mass index (BMI) on muscle function is complex, particularly in young adults. In view of increasing prevalence of obesity in our young population, it is important to study the combined effect of BMI and gender on skeletal muscle performance.

Aim: To study the effect of gender and BMI on the amount of work done by forearm skeletal muscles using Mosso's Ergograph in first-year medical students.

Materials & Methods: This cross-sectional analytical study included 142 first-year MBBS students aged 18–20 years. BMI was calculated using standard anthropometric techniques and categorized as per Asian cut-offs. Forearm muscle performance was assessed using Mosso's Ergograph. A two-way ANOVA was performed to examine the main and interaction effects of gender and BMI category.

Results: Males exhibited significantly greater mean work output than females across all BMI categories ($p < 0.0001$). BMI category also showed a significant main effect ($p = 0.0173$). A significant gender \times BMI interaction was observed ($p < 0.0001$), indicating that the impact of BMI on work performance varied by gender. Obese females showed the greatest decline in muscle performance.

Conclusion & Significance: The study highlights the differential impact of gender and BMI on skeletal muscle performance. These findings underscore the importance of considering both sex and adiposity in functional assessments, especially in young adult populations.

Keywords: Cross-sectional study, Obesity, Skeletal muscle performance

Journal of Research in Medical and Interpathy Sciences. 3(2);2025; doi: 10.61081/jremedis/3v2i102

INTRODUCTION

Skeletal muscle performance is an important factor in maintaining the physical capacity of an individual. It determines the ability to perform day-to-day activities and sustain prolonged physical work. BMI and gender are important determinants of muscle performance. It has been found that obesity can influence skeletal muscle function in different ways. Some studies have reported that obese individuals have greater absolute muscle strength due to the chronic load on muscles from excess body weight. However, when strength is expressed relative to body mass, it is often reduced, particularly in muscles involved in weight-bearing activity.¹ Some authors have reported that excess adiposity can reduce muscle quality due to fat infiltration, reduced oxidative metabolism, and anabolic resistance, which may lead to lower performance despite preserved or increased muscle mass.²

Other studies in older populations have shown that the presence of both high adiposity and low muscle mass, known as sarcopenic obesity, leads to significantly reduced muscle strength and endurance.³ While these age-related changes

Department of Physiology, SMBT Institute of Medical Sciences & Research Center, Dhangaon, Nashik, Maharashtra, India

Corresponding Author: Priyanka Mourya
(Email: mouryapriyanka901@gmail.com)

Conflict of Interest: None

Source of Funding: None

How to cite: Mourya P, Chitale M. Gender and Body Mass Index Association with Skeletal Muscle Work Output in Young Adults: A Cross-Sectional Study Using Mosso's Ergograph. *Journal of Research in Medical and Interpathy Sciences. 2025;3(2):40–43*

are less marked in young adults, similar alterations in muscle quality may occur in persons with higher BMI.

Gender differences in skeletal muscle performance are also well documented. Males generally have greater muscle mass and strength than females, especially in the upper limb muscles, due to hormonal and structural factors.⁴ However, some studies have found that although men produce greater absolute force, the rate of muscle fatigue in certain muscle

groups, such as the forearm muscles, may be similar between genders.⁵

In view of increasing prevalence of obesity in our young population,⁶ it is important to study the combined effect of BMI and gender on skeletal muscle performance. The present study aims to assess this relationship by measuring the amount of work done by the forearm skeletal muscles using Mosso's Ergograph in first-year medical students.

Aim

To study the effect of gender and BMI on the amount of work done by forearm skeletal muscles using Mosso's Ergograph in first-year medical students.

Objectives

1. To compare the work performance of skeletal forearm muscles across different categories of gender and BMI.
2. To measure the maximum amount of work done by the forearm skeletal muscles using Mosso's Ergograph in male and female students.
3. To classify the students into different BMI categories according to the Asian population cut-offs.

METHODOLOGY

Study design

This is a cross-sectional, analytical study.

Study setting

Department of Physiology at a medical teaching institute.

Study population

First-year MBBS students aged 18–20 years of both genders.

Inclusion criteria

- Willingness to participate in the study.
- Performing light to moderate physical activity (as assessed by the short International Physical Activity Questionnaire, IPAQ).
- Free from acute or chronic illnesses.
- Not taking long-term medications for any indication.

Exclusion criteria

- Unwilling to participate.
- More than 20 years of age.
- Engaged in heavy physical activity (IPAQ score >1500 METs).
- Smokers or tobacco users.
- Fasting or skipped meals on the day of the test.

Sample size: The sample size was estimated with the help of the correlation coefficient ($r = 0.1975$) published in the previous literature (Mishra C *et al.*, 2018)⁷

- Probability was considered as 0.02 for which $Z_{(1-\alpha/2)} = 2.33$
- Hence, sample size is $= Z^2_{(1-\alpha/2)} / r^2 + 1 = [(2.33)^2 / 0.1975^2] + 1 = 140.18$

- Hence, final sample size is considered as 141.

The assessment of **physical activity** was done by the "short international physical activity questionnaire" (IPAQ). With the help of this questionnaire, the Metabolic equivalents (MET) for each volunteer were calculated. As per the IPAQ guide, the volunteers scoring less than 600 MET were classified as doing mild physical activity, those scoring between 600-1500 MET were classified as doing moderate physical activity, and volunteers scoring >1500 MET were classified as doing heavy physical activity. Subjects performing heavy physical activity were excluded. This questionnaire is validated for use in India.⁸

BMI Measurement

Height was measured in centimeters using a stadiometer. Weight was measured in kilograms using a calibrated weighing scale. BMI was calculated as:

$$\text{BMI} = \text{Weight in kg} / (\text{Height in meters})^2$$

BMI categories were defined as per Asian cut-offs: Underweight (<18), Normal (18–22.9), Overweight (23–24.9), Obese (≥ 25).

Measurement of Muscle Performance

The skeletal muscle work performance (MP) was calculated as amount of work done by forearm skeletal muscles using Mosso's Ergograph by standard procedure. The subject's forearm was fixed, and repeated flexion of the fingers was performed against a 1.5 kg load at a fixed rhythm until fatigue. The total work done was calculated in kg·m.

Data Analysis

Statistical analysis was performed using Jamovi version 2.6.44.0. Data were represented as mean \pm SD for continuous variables and numbers and frequencies for categorical variables. A two-way ANOVA was conducted to examine the influence of gender and BMI categories on skeletal muscle performance (MP). Post-hoc pairwise comparisons were performed using Tukey's Honestly Significant Difference (HSD) test to identify specific group differences. The significance level was set at $p < 0.05$. Assumptions of normality and homogeneity of variances were checked prior to analysis.

RESULTS

145 students participated in the study. The data for 3 students was excluded due to incomplete information. Figure 1 represents both the gender-wise distribution of participants and the corresponding mean BMI values for each group.

Table 1 presents Mean work done by forearm muscles (MP) in each BMI category, separately for males and females. Table 2 represents the association of gender and BMI on MP. It also demonstrates the combined interaction of BMI and gender with the MP. The main effects of both gender ($F(1,134) = 92.24, p < 0.0001$) and BMI category ($F(3,134) = 3.50,$

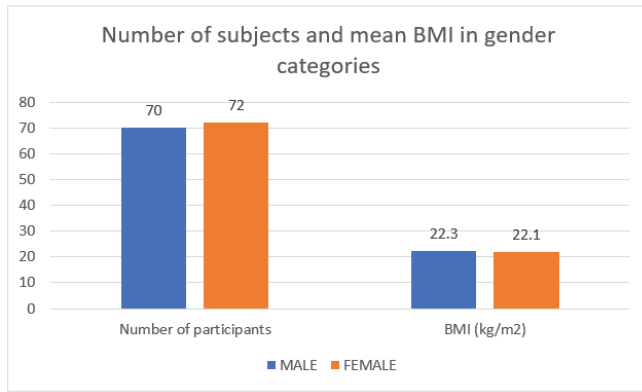


Figure 1: Number of participants and mean BMI in each gender category.

Table 1: Mean work done in each BMI category, separately for males and females.

BMI Category	MP (kgm) (Female)	MP (kgm) (Male)
Underweight	1.18	1.52
Normal	1.17	2.68
Overweight	1.73	2.14
Obese	1.52	1.96

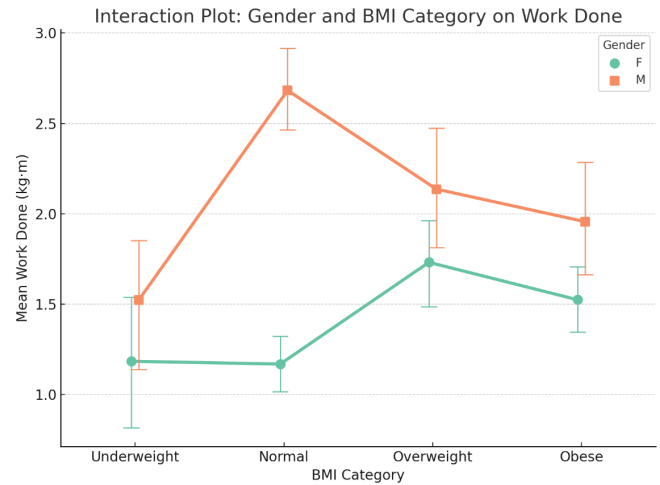
$p = 0.0173$) were found to be statistically significant. Moreover, significant interaction was observed between gender and BMI category ($F(3,134) = 10.65, p < 0.0001$), indicating that the effect of BMI on MP varied by gender. Post-hoc analysis using Tukey’s HSD revealed that obese individuals, particularly females, had significantly reduced MP compared to normal-weight peers.

Figure 2 represents the interaction of gender and BMI with MP. This plot visually represents the combined influence of gender and BMI category on the MP. Across all BMI categories, males consistently demonstrated greater work output than females. Notably, the decline in performance with increasing BMI was more pronounced in females, particularly in the obese category.

Table 2: 2-way ANOVA results showing Main and interaction effects of gender and BMI on amount of muscle work done.

Source	Sum of Squares	df	F-value	p-value
Sex	30.47	1	92.24	< 0.0001**
BMI Category	3.47	3	3.50	0.0173 *
Sex × BMI Category	10.55	3	10.65	< 0.0001 **
Residual	44.26	134	—	—

* = statistically significant; ** = statistically highly significant



* = Work done = MP (muscle performance)

Figure 2: Gender and BMI interaction showing variations in amount of muscle work done.

DISCUSSION

The present study investigated the combined effects of gender and BMI on mp, as measured by Mosso’s Ergograph, in first-year medical students. Our findings revealed significant main effects of both gender and BMI, as well as a notable interaction between these variables, suggesting that the relationship between BMI and MP is moderated by gender.

Key Findings and Interpretations

Gender Differences in Muscle Performance (MP)

In the present study, males consistently exhibited higher work output compared to females across all BMI categories, a finding that aligns well with earlier reports.^{5,9} This gender-based difference can be explained based on biological factors such as greater muscle mass and androgen-mediated hypertrophy in males.¹⁰ Interestingly, this difference in performance narrowed among obese individuals, suggesting a possible influence of obesity-related metabolic factors—such as intramuscular fat infiltration—on muscle quality, particularly in males.¹ Such findings reflect the possibility that in obese males, MP may be more susceptible to metabolic compromise despite greater muscle mass.

BMI and Muscle Performance

Participants with normal and overweight BMI generally demonstrated superior work output compared to their underweight and obese counterparts. This supports the concept of the “obesity paradox” wherein absolute muscle strength may initially increase with BMI due to larger body mass, but performance per unit body weight or muscle quality may eventually decline.¹¹ The findings partially diverge from studies reporting a direct inverse relationship between BMI and muscle strength, possibly due to differences in participant age groups. Unlike studies conducted in older or

sedentary adults,³ our younger sample might exhibit better neuromuscular compensation, thus mitigating the early effects of sarcopenic obesity.

Interaction Effects of Gender and BMI

A statistically significant interaction between gender and BMI category ($p < 0.0001$) indicates that BMI influences males and females differently in terms of MP. Notably, obese females demonstrated a sharper decline in work done compared to obese males. This disparity could be due to several reasons. Hormonal factors, such as estrogen's role in fat distribution and muscle function, might contribute to greater performance decline in obese females.¹² Additionally, gender differences in habitual physical activity, social expectations, and resistance training practices may further compound these outcomes. On the other hand, the relatively better performance of obese males may reflect a delayed onset of sarcopenic features or a greater capacity to retain muscle function under metabolic stress (Morgan *et al.*, 2020)¹³ These findings highlight the compounded impact of gender and BMI on neuromuscular endurance.

CONCLUSION

Together, these findings highlight the complex and interacting roles of gender and BMI on skeletal muscle performance. While males generally outperform females in absolute terms, obesity appears to dampen this advantage, possibly leveling performance metrics across genders. The data suggest that BMI should not be viewed in isolation but in conjunction with gender, physical activity status, and age when assessing muscle performance. Future studies incorporating body composition measures and hormonal profiles may further clarify the underlying mechanisms.

Significance

Obesity is associated with variable decrease in muscle performance for males and females. Muscle-strengthening exercises should be an integral part of obesity management plan.

Limitations

Due to the cross-sectional design of the study, cause-effect relation cannot be established. Use of other methods of obesity, like body composition analysis, might have provided better clarity in results.

Future Directions

Longitudinal studies with body composition analysis (e.g., bioelectrical impedance) and broader age ranges could clarify mechanistic pathways.

REFERENCES

- Tomlinson DJ, Erskine RM, Morse CI, Winwood K, Onambélé GL. The impact of obesity on skeletal muscle strength and structure through adolescence to old age. *Biogerontology*. 2016;17(3):467-83. doi:10.1007/s10522-015-9626-4.
- Morgan PT, Smeuninx B, Breen L, Phillips BE. Age, obesity, sarcopenia and the effect of diet and exercise on skeletal muscle. *Nutrients*. 2020;12(9):2919. doi:10.3390/nu12092919.
- Batsis JA, Villareal DT. Sarcopenic obesity in older adults: aetiology, epidemiology and treatment strategies. *Nat Rev Endocrinol*. 2018;14(9):513-37. doi:10.1038/s41574-018-0062-9.
- Miller AE, MacDougall JD, Tarnopolsky MA, Sale DG. Gender differences in strength and muscle fiber characteristics. *Eur J Appl Physiol Occup Physiol*. 1993;66(3):254-62. doi:10.1007/BF00235103. PMID: 8477683
- Gonzales JU, Scheuermann BW. Gender differences in the fatigability of the forearm muscles. *Med Sci Sports Exerc*. 2007;39(1):57-62. doi:10.1249/01.mss.0000239396.47519.2a.
- Hadaye RS, Manapurath RM, Gadapani BP. Obesity prevalence and determinants among young adults, with special focus on normal-weight obesity; a cross-sectional study in Mumbai. *Indian J Community Med* 2020;45:358-62
- Singh S, Misra C. To Study The Correlation Between Fatigue And Body Mass Index (BMI) Using Mosso's Ergograph In Young Adults. *EJMR*. 2018; 5(2):146-150. DOI:10.24041/ejmr2018.82
- Shenoy S, Chawla JK, Sandhu JS. Validation of short international physical activity questionnaire Punjabi version in India. *Saudi J Sports Med*. 2014;14:77-82
- Miller AE, MacDougall JD, Tarnopolsky MA, Sale DG. Gender differences in strength and muscle fiber characteristics. *Eur J Appl Physiol Occup Physiol*. 1993;66(3):254-62. doi:10.1007/BF00235103.
- West DW, Burd NA, Tang JE, et al. Elevations in ostensibly anabolic hormones with resistance exercise enhance neither training-induced muscle hypertrophy nor strength of the elbow flexors. *J Appl Physiol*. 2012;108(1):60-7. doi:10.1152/jappphysiol.01147.2009.
- Rolland Y, Lauwers-Cances V, Pahor M, Fillaux J, Grandjean H, Vellas B. Muscle strength in obese elderly women: effect of recreational physical activity in a cross-sectional study. *Am J Clin Nutr*. 2009;79(4):552-7. doi:10.1093/ajcn/79.4.552.
- Hicks KM, Onambélé-Pearson GL, Winwood K, Morse CI. Gender differences in fascicular lengthening during eccentric contraction: the role of the patellar tendon stiffness. *Acta Physiol*. 2021;221(3):177-89. doi:10.1111/apha.12601.
- Morgan PT, Smeuninx B, Breen L, Phillips BE. Age, obesity, sarcopenia and the effect of diet and exercise on skeletal muscle. *Nutrients*. 2020;12(9):2919. doi:10.3390/nu12092919.