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# Study of correlation between BMI and amount of work performed by the forearm skeletal muscles by using Mosso's Ergograph in 1st year medical students

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**Abstract**
**Introduction:** Obesity has increased to significant levels in the young population also. It has been found that the presence of obesity also affects the skeletal muscle performance, which can prevent the amount of physical activity or exercise that a person can perform.
**Aim:** To study the association between BMI and amount of work performed by the forearm skeletal muscles by using Mosso's Ergograph in 1st year medical students.
**Methods:** This is a cross sectional, analytical study. BMI was recorded with standard technique in the 1st professional medical students. Amount of work done by the forearm skeletal muscles was measured by the Mosso's Ergograph by standard procedure.
**Results:** Pearson correlation analysis revealed that there was a weak negative correlation between amount of work done and BMI of the subjects ($r = -0.11$, $p = 0.18$). As per the one-way ANOVA and post hoc analysis, obese subjects had a significantly low amount of work done as compared to normal subjects.
**Conclusion:** Skeletal muscle performance in obese subjects is lower as compared to normal weight group. This might lead to early fatiguability in the obese persons.

**Keywords:** BMI, Mosso's Ergograph, performance, skeletal muscle

## Introduction
Obesity has increased to significant levels (40.01%) in the young population also [1]. Physical activity or exercise is the most important tool to prevent or reduce the overweight/obesity problem. It has been found that the presence of obesity also affects the skeletal muscle performance, which can affect the amount of physical activity or exercise that a person can perform. Some studies have reported early onset fatigue in obese people during muscular exercise. Some studies have also reported opposite results [2, 3]. Some studies have also reported increased subjective fatigue perception in obese persons as compared to non-obese persons [2]. If physical activity in obese persons is limited due to decreased work performance or early onset of fatigue, it will initiate a vicious cycle of increasing obesity. Medical profession is a physically exhausting discipline where doctors need to be physically active for long periods. In view of the increasing prevalence of obesity among young adults and changing dietary practices, it is useful to ascertain whether obesity, as defined by the BMI, affects the skeletal muscle performance of young medical students.

## Aim
We aim to study the association between BMI and amount of work performed by the forearm skeletal muscles by using Mosso's Ergograph in 1st year medical students.

## Objectives
1. To measure work performance of the forearm skeletal muscles by calculating the maximum amount of work done on the Mosso's Ergograph.
2. To calculate the degree of correlation between BMI and the work performance.
3. To compare the mean amount of work done between normal and overweight/obese medical students, separately for males and females.

**Type of study:** This is a cross sectional, analytical study.

**Methods**
After getting the ethical approval, the study was carried on in the department of physiology. The subjects were recruited on the basis of the following criteria.

**Inclusion criteria for subjects**
- The subjects will be medical students aged between 18-20 years of both genders
- Willing to participate in the study.
- Should only be performing light to moderate physical activity.
- Should be free from illnesses.
- Not taking any medicines for any indication

**Exclusion criteria**
- Unwilling to participate.
- More than 20 years of age.
- Engaged in heavy physical activity.
- Smokers/tobacco users.
- Any acute or chronic illness.
- Usage of long-term medications for any indication.
- Fasting/ skipped meals.

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 [4].

**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) [3].

Probability was considered as 0.02 for which $Z_{(1-\alpha/2)} = 2.33$
So sample size is = $Z^2_{(1-\alpha/2)} / r^2 + 1 = [ (2.33)^2 / 0.1975^2 ] + 1 = 140.18$
So final sample size is considered as 141.

**BMI**
Body mass index (BMI) was calculated as per the given formula.

BMI = Weight in kg/ (Height in meters)

Height was measured in centimeters (cm) with the help of measuring tape. The subjects were asked to stand erect and look straight ahead. Weight was measured in kilograms (kg).
For the classification of obesity according to BMI, following are the cut-off points for our population as per the revised guidelines [5].
Classification of obesity For Asian Population (Cut off points for BMI)
Classification BMI (kg/m2)
Normal 18-22.9
Overweight 23.0-24.9
Obese > 25.0

**Amount of work done**
It was measured by the Mosso's Ergograph by standard procedure. Work done is calculated in kg m.
Subjects with greater amount of work done will be said to have delayed onset of fatigue.

**Procedure**
**The following steps are followed**
After obtaining informed consent, the subjects were asked to answer the IPAQ short form, for grading of physical activity. The eligible subjects were explained the procedure for Ergograph and the record of the procedure was made as follows:
1. The right forearm (left forearm in left handed persons) was fixed on the Ergograph and index and ring fingers are fixed in the finger holders.
2. With the middle finger extended and the string with the cord attached to it, a weight of 1.5 kg on the hook was applied.
3. The beat of the metronome was adjusted at 30 / minute, i.e. one beat every 2 seconds. The subject was asked to contract the flexor muscles maximally and rhythmically, following each beat of the metronome, and to continue (without moving the shoulders) until fatigue was so great that the weight can no longer be lifted.
4. Calculation of work done: The work done was calculated in each case as shown below:

Work done (in kg meters) = Weight lifted × Distance
(The distance through which the weight is lifted is the sum of all the heights of contractions, converted to meters).

**Data analysis**
Statistical analysis was done on Microsoft Excel 2021 MSO (Version 2401).
Subjects were divided into normal & overweight/obese categories as per the BMI.
Mean amount of work done was calculated for each category. Mean amount of work done was compared across categories by one way ANOVA.
Pearson's Correlation coefficient between BMI and amount of work done was calculated. Its statistical significance was calculated by the t-score.

**Results**
170 students had volunteered for the study. On the basis of their IPAQ scores, only 142 were included in the study. There were 72 females and 70 males among the study subjects.

**Table 1:** Shows the baseline characteristics of the population. All values are Mean ± SD.

| Baseline characteristics of population | |
|---|---|
| Number of subjects (N) | 142 |
| BMI (kg/m2) | 22.2±3.3 |
| Amount of work done (kg) | 2.1±0.8 |
| IPAQ score (MET) | 1237.7±909.4 |

BMI-Body mass Index, IPAQ-International physical activity questionnaire, MET-Metabolic Equivalents.

The Pearson correlation analysis revealed that there was a weak negative correlation between amount of work done and BMI of the subjects (r = -0.11, p = 0.18). Figure 1 demonstrates this relationship.

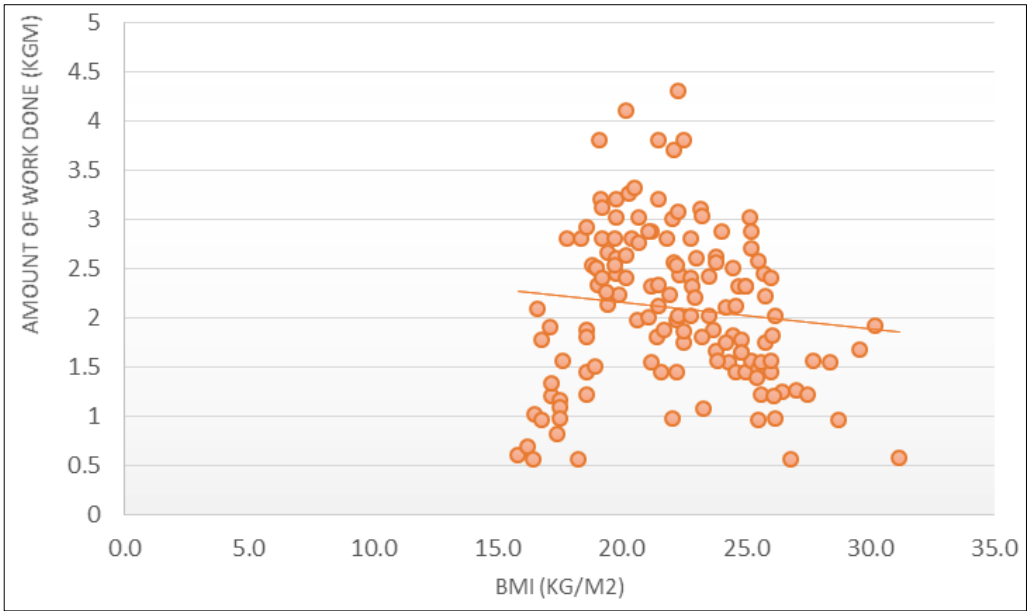


**Fig 1:** Correlation between BMI & Amount of work done by the forearm muscles

The study population was divided into 4 categories according to their BMI to compare the mean amount of work done by subjects in each category. A one-way ANOVA was performed to compare the effect of BMI on the mean amount of work done. As per the one way ANOVA, a significant difference was present in the means of at least 2 groups (F (3, 138) = [20.5], $p$<0.001, Table 2).

**Table 2:** Comparison of work done by forearm muscles in different BMI categories

| BMI (kg/m$^2$) categories | Underweight (<18.0) | Normal (18-22.9) | Overweight (23.0-24.9) | Obese (> 25.0) | ANOVA |
|---|---|---|---|---|---|
| N | 16 | 68 | 25 | 33 | |
| Mean BMI±SD | 17±0.5 | 20.6±1.4 | 24.0±0.6 | 26.4±1.5 | |
| Mean Amount of work done ± SD | 1.3±0.4 | 2.5±0.5 | 2.1±0.3 | 1.7±0.4 | F (3, 138) = [20.5], $p$<0.001 |

Post hoc comparisons using t Test with Bonferroni correction, indicated the underweight group had significantly less mean as compared to the normal BMI as well as the overweight BMI group. The normal BMI group and the overweight BMI group did not have significantly different means. The obese group had a significantly less mean than that of normal BMI group. But the means of obese and overweight groups did not differ significantly.

**MET Scores**

As per the IPAQ questionnaire, 73.4% of subjects engaged in moderate level of physical activity and 26.5% of subjects engaged in mild level of physical activity.

**Discussion**

This study compared the amount of work done by forearm skeletal muscles by subjects of different BMI. The amount of work done by the muscles is limited by the onset of fatigue. Our study has found that the total amount of work done by forearm muscles goes on decreasing with increase in the BMI. But the statistical association between them is not significant.

As per the one-way ANOVA, the overweight group had a lower mean amount of work done as compared to the normal BMI group and further the obese group had a lower mean amount of work done as compared to the overweight group. But the truly significant difference was only present between the normal BMI group and the obese group in the post hoc analysis.

So, our results show that the amount of work done by forearm skeletal muscles goes on decreasing and the hence the onset of fatigue sets in early as the BMI goes on increasing. But the effect is strongly apparent only when we compare obese BMI group with normal BMI group.

Mishra *et al.* (2018) [3] conducted a similar study but found opposite results as compared to this study [3]. In their study, subjects with higher BMI were able to perform higher mean amount of work on the Ergograph by forearm skeletal muscles. Sandeep S (2020) also conducted a similar study with exclusive male population [6]. Their study agrees with our study and the subjects with higher BMI had a significantly low amount of work on the Ergograph. They also measured endurance time with the help of handgrip dynamometer, and found lower endurance time in subjects in the obese group. Both findings suggest early fatiguability of the muscle in obese persons.

Other methods have also been used to compare fatiguability and strength of skeletal muscle in normal weight and obese subjects. Hasan *et al.* (2016) studied muscle strength and endurance time in children (10-13 years) of both genders with the help of Isokinetic Dynamometer [7]. The muscle strength was significantly increased in the quadriceps and triceps of the obese children. But the endurance time was

significantly decreased in both as BMI increased, though statistical significance was present only for the quadriceps.

Pajoutan *et al.* (2017), studied the effect of obesity on the central fatigue and peripheral fatigue in the deltoid muscle of young healthy adults [8].

Obese subjects had significantly reduced capacity to activate the motor units towards the end of experiment as compared with the normal BMI group, hence resulting in early fatigue in obese subjects. Although the peripheral fatigue was similar in both groups. So, the authors concluded that obese people experience early fatigue development due to central mechanisms

Tallis *et al.* (2017) studied isolated skeletal muscle preparations of obese and lean mice [9]. They conclude that the skeletal muscles in the obese mice develop fatigue earlier as compared to the lean group. Although the data shows significant results only in case of soleus muscle and not the upper limb muscles, the authors argue that since the absolute power produced by the obese muscle is less, it will develop fatigue faster when trying to produce the same power as the lean muscle.

Muscle fatigue is a result of saturation of oxidative metabolism and start of anaerobic metabolism. A muscle having more oxidative capacity will be able to perform more work and fatigue will set in late in such a muscle [10]. Reduced insulin mediated glucose uptake and increased lactate production has been observed in skeletal muscle samples from severely obese persons. Also, studies have identified reduced capacity of fatty acid oxidation due to enzymatic and /or mitochondrial defects [11]. Some studies also reported less type I fibers in muscles in obese people, but this finding is controversial at best [9, 11]. Ability to perform more work and delay fatigue is dependent on oxidative capacity. The above-mentioned evidence shows that pathways of oxidative metabolism may be disturbed in skeletal muscles of severely obese persons-contributing to early fatigue. Obesity leads to insulin resistance, and studies have found that it reduces the AMPK (5′-adenosine monophosphate-activated protein kinase) activity and calcium signaling in myocytes. Both AMPK activity and Calcium signaling pathways are important in the conversion of fast muscle fibers to slow muscle fibers as well as in myogenesis. So, low percentage of slow muscle fibers and low muscle mass may be responsible for early fatiguability or low capacity to perform work in obese subjects [12].

## Conclusion

Skeletal muscle fatigue is both a physical and psychological phenomenon. Although our study could not find a statistically significant correlation between BMI and amount of work done, but we did find that the obese subjects could perform a significantly less amount of work as compared to the normal subjects. The intermediate amount of work done by the overweight group could account for the weak correlation obtained in our study. So, a higher BMI is associated with reduced amount of work done by the skeletal muscles and early fatiguability in young adults too.

## Strengths and Limitations

In our study we specifically excluded persons with high intensity physical activity to avoid the effect of exercise on muscle performance, which was not done in the previous studies.

The skeletal muscles of lower muscles also need to be studied for the effect of obesity upon them, which we could not do due to lack of instruments.

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