

Original research article

## To Study Correlation of Waist Circumference and Muscle Fatigue in Young Adults Using Mosso's Ergograph

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### Abstract

**Background:** Obesity is greatly associated with functional limitations in muscular performance and increased likelihood of developing functional disability like mobility, strength, postural and dynamic balance limitations. However, the consensus is that obese individuals, regardless of age, may have greater absolute maximum muscle strength as compared to lean individuals.

**Aim:** To study association between waist circumference and muscle fatigue using Mosso's Ergograph in lean and obese young adults.

**Material & Methods:** This cross sectional study included 200 subjects between 18-24 years of age fulfilling inclusion criteria of age and abdominal obesity  $\geq 90$  cms and exclusion of any chronic disorders. They were divided into lean group (n=100) with a waist circumference  $< 90$ cm and obese group (n=100) with a waist circumference  $\geq 90$  cm and underwent fatigue test using Mosso's Ergograph and the work done (Kgm) was calculated and correlated with waist circumference.

**Results:** A positive correlation between waist circumference (77.66 $\pm$ 7.31 cm for lean and 88.38 $\pm$ 4.60cm for obese) and work done (3.61 $\pm$ 1.28 Kg.m in lean and 3.39 $\pm$ 1.74 in obese) which was found to be  $r = 0.42$  for lean and  $r = 0.68$  for obese individuals was observed and was found to be statistically significant ( $p = 0.03$ ) in obese but not in lean group ( $p = 0.21$ ).

**Conclusion:** The results indicate that obese individuals have greater absolute maximum muscle strength and hence fatigue lesser when compared with lean individuals.

### Introduction

Muscles are the only tissues in the body that have the ability to contract and hence move the other parts of the body. Physical activity is the one important factor which affects the skeletal muscle function. The strength of any given muscle, in terms of force exerted on the skeleton depends upon length, shortening speed, cross-sectional area, sarcomere length, myosin isoforms and neural activation of motor units.<sup>(1)</sup> Skeletal muscle fatigue is defined as the fall of force or power in response to contractile activity. Both the mechanisms of fatigue and the modes used to elicit it vary tremendously.<sup>(2)</sup> Obesity is greatly associated with functional limitations in muscular performance and increased likelihood of developing functional disability like mobility, strength, postural and dynamic balance limitations. Simple

anthropometric measurements have been used as surrogate measurements of obesity and have more practical value in both clinical practice and for large-scale epidemiological studies.<sup>(3)</sup>

Waist circumference is a simple anthropometric measurement that provides a unique indicator of body fat distribution, which helps in identifying patients who are at increased risk for obesity-related cardiometabolic disease, above and beyond the measurement of BMI.

The aim of this study was to find a correlation, if any, between waist circumference and fatigability in lean and obese young adults using Mosso's Ergograph.

### Material and Methods:

- This cross-sectional study was done at Rajarshi Dashrath Autonomous State Medical College, Ayodhya in the Department of Physiology. The study was conducted after taking ethical clearance from the institutional ethical committee.

- Study Population: 200 Young healthy attendants of patients visiting the OPD of Rajarshi Dashrath Autonomous State Medical College, Ayodhya between 18-24 years of age were selected for the study.<sup>(4)</sup> A waist circumference  $\geq 90$ cm for obese and  $\leq 90$ cm for lean individuals was taken into account.<sup>(5)</sup> A written informed consent was taken and subjects were explained the procedure in detail.

Individuals with a history of alcohol, tobacco consumption and on drugs (corticosteroids, beta blockers), history of any apparently known chronic diseases, any upper limb physical disability or any mental illness were excluded from the study.

The first 100 subjects with a waist circumference  $< 90$ cm were taken as lean group (N = 100) and the next 100 with a waist circumference  $\geq 90$ cm as obese group (N = 100)

They underwent fatigue test using Mosso's Ergograph. The subject's forearm was fixed on the ergograph using clamps. The middle finger was put in the loop to pull a weight of 2 kg and the index and ring fingers were inserted into fixed metal tubes provided in the ergograph. The sliding plate is fitted with a chart holder. A pencil or a pen was fitted vertically over the chart paper so as to record the movements of the chart holder when it moved. Thereafter, the subject was asked to make a series of maximal contractions without moving the shoulders until fatigue was so great that the weight could no longer be pulled. Muscle fatigue was calculated as a function of work done by the exercising muscles in kilo gram and was correlated with waist circumference.

Work done was calculated by the formula <sup>(6)</sup>

$$W = F \times D$$

Where, W: Work done (in Kgm)

$$F = \text{weight lifted (kg)}$$

Here, D (cm) = No. Of contractions X average height of contraction (A in cm),

Where, A =  $\frac{\text{Area of triangle} + \text{Area of Rectangle}}{\text{Total length of the base}}$

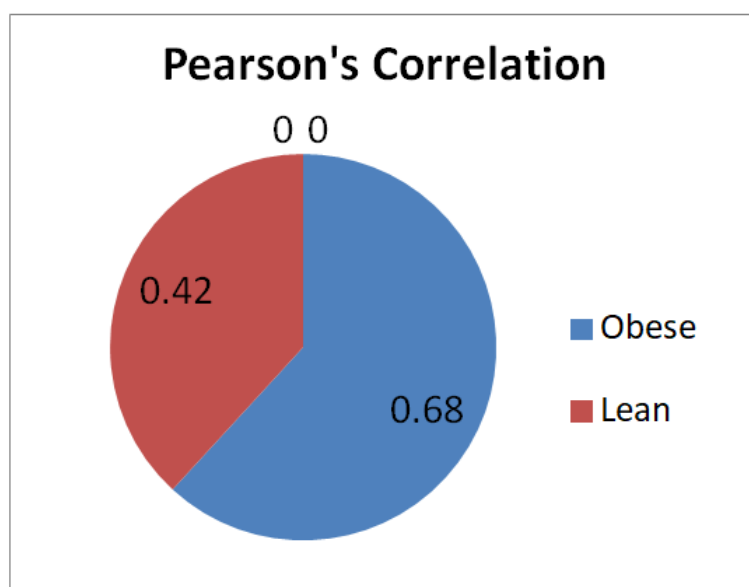
Data was analyzed using SPSS Verion 20.0

### Results:

There is a positive correlation between waist circumference (77.66 $\pm$ 7.31 cm for lean and 88.38 $\pm$ 4.60 cm for obese) and work done (3.61 $\pm$ 1.28 Kg.m in lean and 3.39 $\pm$ 1.74 in obese) which was found to be  $r = 0.42$  for lean and  $r = 0.68$  for obese individuals and was found to be statistically significant ( $p = 0.03$ ) in obese but not in lean group ( $p = 0.21$ ) (Table 1).

**Table 1: Showing correlation of waist circumference with muscle fatigue in lean and obese group**

LEAN	Mean+- SD	77.66±7.31	3.61±1.28
	Pearson's Correlation(r)	0.42	
	p value	<b>0.21(NS)</b>	
	N	100	100
OBESE	Mean± SD	88.38±4.60	3.39±1.74
	Pearson's Correlation (r)	0.68	
	p value	<b>0.03 (S)</b>	
	N	100	100

**Figure 1: Pie Chart showing association of waist circumference with Muscle fatigue in lean and obese group****Discussion:**

Muscles make up more than 40% of body mass so they represent a substantial site of energy metabolism. Isotonic exercise is one of the reliable methods of measurement of muscle strength and fatigue of a single muscle or a group of muscles under controlled conditions.

The degree, duration and type of work have been the most important factors that affect the performance and onset of fatigue. Fatigue can either be subjective i.e. feeling of tiredness or objective i.e. measurable decrease in performance and these phenomena are interdependent. The development of skeletal muscle fatigue in voluntary contracting muscles can be shown by using an Mosso's Ergograph wherein work is performed by pulling a weight. Mosso's Ergograph is a simple manual device that measures fatigability as a function of work done by the exercising muscles and has long been considered a kind of "Gold Standard" for measuring fatigability. Mosso's Ergograph has an advantage over other techniques because it

helps in isolation of muscle to be used and also makes the conditions of load and registration as nearly as possible like those in experiments.<sup>(7)</sup>

Waist circumference is a convenient measure of abdominal fat and is considered to be a reliable measure of adiposity in males and females. However, the consensus is that obese individuals, regardless of age, have greater absolute maximal muscle strength as compared to lean individuals. Whilst precise, sophisticated techniques for measuring body fat distribution and body composition are available, they are generally not considered appropriate outside specific research settings.<sup>(8,9)</sup> Accordingly, waist circumference represent a promising tool for estimating skeletal muscle, muscle strength and consequently fatigability when direct measurements are not available/ feasible. As per the International Diabetes Federation (IDF), waist circumference is an important anthropometric parameter for abdominal obesity. The key finding of this study was that waist circumference in obese group was more strongly associated with work done as compared to the lean group. Since muscle fatigue is a function of work done, it proves that the obese group which had a greater waist circumference than lean group showed more work done hence fatigued lesser.

Tomlinson et al. (2016) reported that loaded muscles were stronger in obese than lean in antigravity muscles suggesting that additional body mass may act as a training stimulus thus increasing muscle size and strength without any effect on muscle quality<sup>(10)</sup>. Lafortuna et al.<sup>(11)</sup> have examined the effect obesity has on maximal isotonic strength and Tomlinson et al.<sup>(12)</sup> studied on isometric strengths while Blinkie et al.<sup>(13)</sup> Maffiuletti et al.<sup>(14)</sup> Hulens et al.<sup>(15)</sup> Delmonico et al.<sup>(16)</sup> and Hilton et al.<sup>(17)</sup> reported on isokinetic strength in a variety of age classifications. The majority of these studies, agree that absolute strength is higher in obese compared to non-obese individuals, and the consensus between all studies is that strength is lower in the lean individuals as compared to obese and hence lean individuals fatigue early as compared to obese individuals.

Interestingly, our study showed similar results as Cavedon et al.<sup>(18)</sup> where they stated that in obese females increasing waist circumference generally reflect increasing amounts of lean soft mass and mineral mass, and higher muscle strength. Such an association was essentially independent of age, suggesting that it is inherent to the obese condition. A second hypothesis tested in this work was that waist circumference was able to predict muscle strength. Overall, findings indicate that waist circumference is a potentially reliable predictor of strength test performance in obesity as compared to lean individuals. All the above studies have been extensively carried out in anti-gravity muscles but none so far for upper limbs. The aim of this study thus, was to observe whether any correlation existed between waist circumference and muscle strength in upper limbs which directly or indirectly affected the work function causing early fatigue in both the lean and obese groups. Compellingly, we found that waist circumference was more strongly and positively correlated with work done in obese group than lean group suggesting that upper limb muscle strength is directly or indirectly affected by an increased waist circumference. However, further work in larger samples of obese and lean individuals is needed to generalize the proposed predictive anthropometric correlation with muscle fatigability in both groups.

### **Conclusion:**

The results indicate that obese individuals have a greater absolute maximal muscle strength and hence fatigue lesser when compared with lean individuals.

In conclusion, this work demonstrated in obese individuals that increasing waist circumference positively correlate with skeletal muscle mass and strength.

### **Conflict of interest:**

No conflict of interest was declared.

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