

## TO STUDY THE CORRELATION BETWEEN FATIGUE AND BODY MASS INDEX (BMI) USING MOSSO'S ERGOGRAPH IN YOUNG ADULTS

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### ABSTRACT

Muscles are the only tissues in the body that have the ability to contract and hence move the other parts of the body. 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. Fatigue is a reversible physiological state in which there is an objective reduction in the performance or its absence resulting from continuous or prolonged activity<sup>1</sup>. The degree, duration and type of work are the important factors that affect the performance and onset of fatigue<sup>3</sup>.

To correlate body mass index (BMI) and muscle fatigability in young healthy adults. This cross sectional study included 100 apparently healthy young adults, both males and females between 18-24 years of age and without a history of alcohol or tobacco consumption, history of any cardiovascular disorders or diabetes mellitus and any drug history like corticosteroids, beta blockers. and underwent fatigue test using Mosso's Ergograph and the work done (Kgm) was calculated and correlated with body mass index.

The results showed a strong positive correlation between Body Mass Index and work done( $r=1$ ) which was found to be statistically significant ( $p<0.05$ ). Moreover, The results showed a very strong positive correlation( $r=1$ ) between different categories of Body Mass Index and the amount of work done by the exercising muscle, but the results were statistically non significant ( $p<0.05$ ) in all the sub categories of body mass index.

A strong positive correlation between Body Mass Index and amount of work done by the exercising muscle suggests that the level of fatigueness in an individual is related to his/her nutritional status and physical fitness.

**KEYWORDS:** Muscle fatigue, Mosso's Ergograph, Body mass index.

### INTRODUCTION

Muscles are the only tissues in the body that have the ability to contract and hence move the other parts of the body. 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. Fatigue is a reversible physiological state in which there is an objective reduction in the performance or its absence resulting from continuous or prolonged activity<sup>1</sup>. A fatigued muscle can recover if given proper rest and nutrition. The causes of recovery are mainly:

1. Removal of metabolites
2. Formation of Acetylcholine at the neuromuscular junction
3. Re-establishment of normal polarized state of the muscle
4. Availability of nutrients
5. Availability of oxygen

The fatigued muscle differs from the fresh

resting muscle because it has acid reaction so it relaxes slowly unlike the fresh resting muscle which is alkaline.

Many muscle properties change during fatigue including the action potential, extracellular and intracellular ions, and many intracellular metabolites. A range of mechanisms have been identified that contribute to the decline of performance. Apart from the traditional explanation, that is, accumulation of intracellular lactate and hydrogen ions causing impaired function of the contractile proteins, alternative explanations considered are the effects of ionic changes on the action potential, failure of sarcoplasmic reticulum  $Ca^{2+}$  release by various mechanisms, and the effects of reactive oxygen species<sup>2</sup>. Muscle fatigue may be due to precise molecular changes that occur *in vivo* with sustained exercise. It has been found that the ryanodine receptor present in skeletal muscle undergoes a conformational change during exercise, resulting in "leaky" channels that are deficient in calcium release. These "leaky" channels may be a contributor to muscle fatigue and decreased exercise capacity<sup>3</sup>.

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So to summarize the main causes of fatigue, it can be due to:

1. Exhaustion of acetylcholine at motor end plate
2. Accumulation of metabolites like lactic acid and phosphoric acid
3. Lack of nutrients like glycogen
4. Lack of oxygen

During isotonic contraction, muscles get a chance for liberal blood flow during relaxation. That is why, circulatory occlusion hastens the onset of fatigue to a much greater extent<sup>4</sup>. It has been proved through various experiments that fatigue developing in maximal voluntary muscular effort first occurs in central nervous system followed by neuromuscular junction and lastly in the muscle proper. Thus, in the intact body, the sites of fatigue are in following order:

1. Betz(pyramidal) cells in cerebral cortex
2. Anterior gray horn cells ( motor neurons) of spinal cord
3. Neuromuscular junction
4. Muscle proper<sup>5</sup>

In the present era of modernization, human beings, specially young adults have mostly restricted themselves to static lifestyle with lesser physical movement. This has led to an abnormal increase in weight which has been found to be associated with various diseases like cardiovascular diseases, type 2 diabetes mellitus, obstructive sleep apnea, certain cancers and osteoarthritis in future. A reliable indicator for body fat is BMI<sup>6,7</sup>. The BMI is an attempt to quantify the amount of tissue mass (muscle, fat, bone) in an individual and then categorize that person as underweight, overweight or obese based on that value. Thus, the present study was conducted to correlate body mass index (BMI) and muscle fatigability in young healthy adults using Mosso's Ergograph.

## METHODOLOGY

**STUDY DESIGN:** The present study was conducted in the Department of Physiology of Era's Lucknow Medical College & Hospital (ELMC&H), Era University, Lucknow. The duration of this study was 6 months from the time of obtaining ethical clearance from the institute's ethical committee.

## SAMPLE POPULATION

Both male and female young, apparently healthy attendants of patients visiting the OPD of Era's Lucknow Medical College & Hospital in the age range of 18-24 years<sup>8</sup> were selected for the study. Subjects with a history of alcohol and tobacco consumption, history of chronic illness like cardiovascular, tuberculosis, hypertension etc, history of diabetes and subjects receiving drugs( corticosteroids, beta

blockers) were excluded from the study.

All the subjects fulfilling the inclusion criteria and not falling into the domain of exclusion criteria were invited to enroll in the study till the sample size requirements were fulfilled. All subjects were explained about the protocol of the study and a written informed consent was obtained.

## SAMPLE SIZE

Sample size was calculated based on the study done by Smisha Mohan, Bagavad Geetha M and Padmavati R<sup>1</sup> on the basis of the formula:

$$n = \frac{Z^2 \alpha^2 \sigma^2}{d^2}$$

Where, = 3.6, standard deviation of work done

Z= standard normal variate

Type I error  $\alpha$ = 5%

d= effect size, 5% of mean work done ( % of 22.9) for detecting results with 90% power of stats.

Then sample size comes out to be: n=100

After enrolment, a general and systemic examination was done and a proper case history was recorded to confirm that the subjects selected were apparently healthy. These subjects then underwent recording of anthropometric parameters like height( in metres) and weight( in kilograms) and Body Mass Index(BMI) was calculated.

**The WHO Criteria for various subgroups of Body Mass Index was taken into consideration (9) i.e.**

Body Mass Index	Range
Underweight	<18.5
Normal	18.5-24.9
Overweight	25-29.9
Obese	>=30

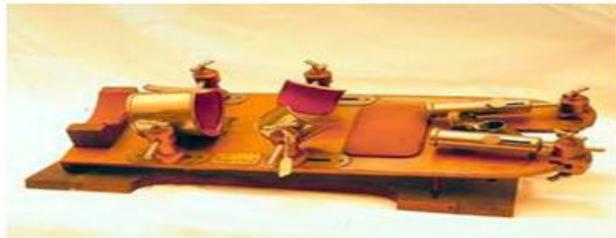
In this study the muscular fatigue was recorded as a function of the amount of work done by the exercising muscle using Mosso's Ergography.

## DETERMINATION OF FATIGUE BY MOSSO'S ERGOGRAPHY

A spring loaded writing ball point pen and a paper on the platform underneath was arranged in the Mosso's Ergograph. The forearm of the subject was fixed on the ergograph by means of clamps. The middle finger was put in the loop to be pulled and the index and the ring fingers were inserted into the fixed metal tubes provided in the ergograph. The subject's position was adjusted at various adjustable points in the ergograph is such a way that the

Subject's forearm was properly fixed and at the same time the subject was comfortable.

With the middle finger extended, a weight of 1.5 kgs was suspended on the ergograph. The subject was asked to make a series of maximal contractions without moving the shoulder. The contractions were continued until fatigue was so great that weight could no longer be lifted. Outcome of the procedure was noted in terms of work done in Kg.m.



**Fig.1 Mosso's Ergograph: Image**

**STATISTICAL ANALYSIS**

- The data so collected was subjected to statistical analysis using Statistical Package For Social Sciences (SPSS) version 20.0
- To correlate BMI with muscle fatigue ( which is a function of work done by the specific muscle) Pearson's Correlation was applied.
- To analyze any statistically significant differences between the means of different categories of BMI i.e. underweight, normal, overweight and obese, in both males and females separately and also combined, One- Way ANOVA was used.
- The confidence limit of the study was 90% hence a 'p' value less than 0.05 was considered to be statistically significant.
- Generation of graphs and tables were done by Microsoft Excel and Microsoft Word version 2007.

**OBSERVATION AND RESULTS**

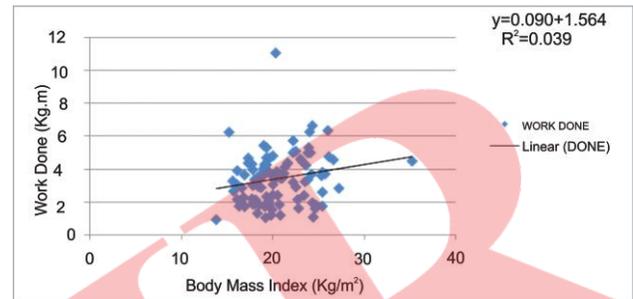
The study was carried out to observe correlation between Body Mass Index (BMI) and muscle fatigue in young adults.

	Underweight (n=27)	Normal (n=47)	Overweight (n=16)	Obese (n=10)	'p' value
Age(years)	20.03±2.19	20.53±1.97	20.81±2.26	21.6±2.2	>0.05
Male%	96	74	75	100	
Weight(kg)	48.67±5.17	55.62±5.95	64.62±6.95	76.6±13.75	
Height(m)	1.69±0.06	1.67±0.07	1.63±0.09	1.68±0.03	
BMI(Kg/m <sup>2</sup> )	17.01±1.12	20.23±1.23	23.92±0.49	26.83±3.00	
Work done(Kg.m)	3.01±1.12	3.54±1.67	3.78±1.68	3.84±1.29	

**Table 1 : Shows comparison of demographic and clinical characteristics amongst underweight, normal, overweight and obese subjects.**

Values are Mean±SD; BMI=Body Mass Index; Analyzed with one way ANOVA

**Table 1.** shows that the mean work done in the underweight subgroup was found to be 3.01±1.12 Kg.m, normal subgroup was 3.54±1.67 Kg.m, overweight subgroup was 3.78±1.68 Kg.m and in the obese subgroup was 3.84±1.29 Kg.m with the mean age being 20.03±2.19 years, 20.53±1.97 years, 20.81±2.26 years and 21.6±2.2 years respectively.



**Fig 2: shows overall scatter plot correlation of work done(Kg.m) with BMI**

**DISCUSSION**

Skeletal muscle is a fascinating biological tissue able to transform chemical energy to mechanical energy. The production of movement and force is the mechanical outcome of skeletal muscle contraction<sup>1</sup>.

Physical inactivity contributes to weight gain in adults<sup>7</sup>. Several studies suggest that an active lifestyle during childhood and adolescence can play an important role in optimizing growth and development<sup>(10,11)</sup>. Muscle function testing is used to measure muscle contraction, fatigue, endurance, strength and physical capacity under varying conditions.

During exercise, it has been observed that defects in Ca<sup>2+</sup> release from the sarcoplasmic reticulum impairs muscle function. Andrew M. Bellinger et al in 2008<sup>3</sup> suggested a possible mechanism by which Ca<sup>2+</sup> leak via calstabin1-depleted Ryanodine (RyR1) channels leads to defective Ca<sup>2+</sup> signaling, muscle damage and impaired exercise capacity.

With this background, the present study was carried out to correlate Body Mass Index (BMI) and muscle fatigue in young adults.

Kader NA et al in the year 2015<sup>12</sup> found a positive correlation of work done with Body Mass Index (R=0.44) which was statistically significant(p<0.001) which coincides with the results of the present study that also shows a positive correlation in the Normal(r=0.05) and Obese( r=0.21) subgroups of BMI. These results also stand in accordance with Maffiuletti et al in 2008<sup>13</sup> who reported significant higher absolute voluntary muscle strength in obese

adolescents which was attributed to working at a shorter muscle length to avoid excessive stress during an activity or sport or to avoid injury. However, the results are in contradiction to the study conducted by Blimkie et al in 1990<sup>14</sup> who reported no significant difference between obese and non-obese groups. This may be attributed to a comparatively smaller sample size. Besides, it may also be attributed to the fact that a fixed weight of 1.5 kg was used for lifting by the exercising muscle to calculate the work done which cannot clearly define the degree of fatigueness in various subgroups of Body Mass Index.

Smisha Mohan et al in 2016<sup>1</sup> reported that sedentary individuals go into fatigue sooner because of inadequate supply of nutrients like oxygen, creatine phosphate, ATP and depletion of neurotransmitters and accumulation of metabolites in the muscles earlier than the exercising individuals. Robert Fitts in 1994<sup>15</sup> suggested that factors which influence onset of fatigue are type of muscle fibres, training and blood flow.

Hence, a positive correlation between Body Mass Index and amount of work done by the exercising muscle suggests that the level of fatigueness in an individual is related to his/her physical fitness, socio-economic status and nutritional status. A poorly nourished individual with a lower BMI (<18.5 kg/m<sup>2</sup>) showed a significant decrease in the work done capacity while a higher BMI (>=30 kg/m<sup>2</sup>) showed a greater absolute maximal muscle strength suggesting that increased adiposity possibly acts as a chronic overload stimulus on the exercising muscles.

## CONCLUSION

Thus, this study prompts for aiming at maintaining physical fitness which can result from a healthier lifestyle in young adults which includes regular exercise, healthy dietary habits and refrainment from tobacco smoking and alcohol consumption that shall go a long way in increasing their work efficiency and productivity with lesser fatigability.

## STUDY LIMITATIONS AND FUTURISTIC PERSPECTIVES

Though, it is a small study, but on the basis of the conclusions drawn, further research work can be undertaken with a larger sample size to ascertain any significant relation between subgroups of Body Mass Index viz. underweight, normal weight, overweight and obese with the degree of fatigability in these subgroups.

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