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## **Comparison of muscle fatigue in prediabetic and normal individuals**

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**Abstract**---It was observed that people with prediabetes had greater performance fatigability of the knee extensors due to contractile mechanisms compared with controls, although less performance fatigability than that of people with Type 2 Diabetes Mellitus. The aim of this study was to compare muscle fatigue in normal and prediabetic individuals. A comparative cross-sectional study was conducted in adults between 24-60 years of age. A total of 100 age matched normal and 100 prediabetic individuals were selected for the study.

Fatigability was calculated as a function of work done by the pleximeter finger of the dominant hand. The work done was categorized broadly into four groups viz. 0-2 kg.m, 2.1-4 kg.m, 4.1-6 kg.m and 6.1 and above. Fatigue test was performed using Mosso's Ergograph. The study was conducted at Rajarshi Dashrath Autonomous State Medical College, Ayodhya. Overall, average work done by prediabetic individuals was lesser (0-2 kg.m=23%, 2.1-4 kg.m=58%, 4.1-6= 17% and 6.1 and above=2%) as compared to normal individuals (0-2 kg.m= 20%, 2.1-4 kg.m= 48%, 4.1-6= 27% and 6.1 and above= 5%). This study aimed at comparing degree of fatigability in prediabetic and normal individuals so that further work can be initiated to improve the quality of life in prediabetics that maybe drastically hampered due to easy fatigability.

**Keywords**---muscle fatigue, mosso's ergograph, prediabetes.

## **Introduction**

Prediabetes has been established as a state of disordered glucose metabolism rather than a distinctive clinical entity that signifies an important risk factor for the development of diabetes<sup>1</sup>. 5-10% of those with prediabetes can progress to diabetes every year. Almost 70% of individuals with prediabetes will eventually develop diabetes according to the American Diabetes Association (ADA) expert panel<sup>2</sup>. Since the flexors of the fingers are used diligently even in an otherwise sedentary lifestyle, so they were assessed in this study. The aim of this study was to compare muscle fatigue in normal and prediabetic individuals that can go a long way in improving the quality of life in prediabetics who presumably struggle due to easy fatigability.

## **Material and Methods**

This comparative cross-sectional study was conducted in the Department of Physiology at Rajarshi Dashrath Autonomous State Medical College, Ayodhya. The Study was conducted after taking ethical clearance from the institutional ethical committee. A total of 200 age matched participants (n=100, normal) and (n=100, prediabetic) between 24-60 years of age were included in the study. Prediabetics were selected from the OPD of the associated hospital and screened based on prediabetes criteria laid down by American Diabetes Association that is Fasting plasma glucose levels (100-125mg/dL) and HbA<sub>1c</sub> level (5.7-6.4%)<sup>2</sup>.

- Mosso's Ergograph was performed on the selected participants after taking a written informed consent. Proper instructions about the procedure were explained to the subjects. The subject's forearm was fixed on the Ergograph by clamps. Middle finger in the loop was pulled and index and ring fingers were fixed into metal tubes. With the middle finger extended, a 2.5 kg weight was suspended. Subject was asked to make a series of maximal contractions without moving the shoulder at regular intervals. Contractions were continued until it occurred no longer. Readings were recorded in the form of a graph<sup>3</sup>.

- Development of fatigue in voluntary contracting muscle was assessed as a function of work done by the muscle in question.

### Calculation of work done

$$W=F*D$$

Where, W= work done (Kg.m)

F= weight lifted (Kg)

D= total distance moved (m)

To get the total distance (D) moved, total length of all the vertical lines was measured i.e. addition of all the vertical amplitudes was done.

### Results

Table 1

Shows group wise distribution of work done in normal individuals

Work Done(kg.m)	N%
0-2	20
2.1-4	48
4.1-6	27
6.1 and above	5

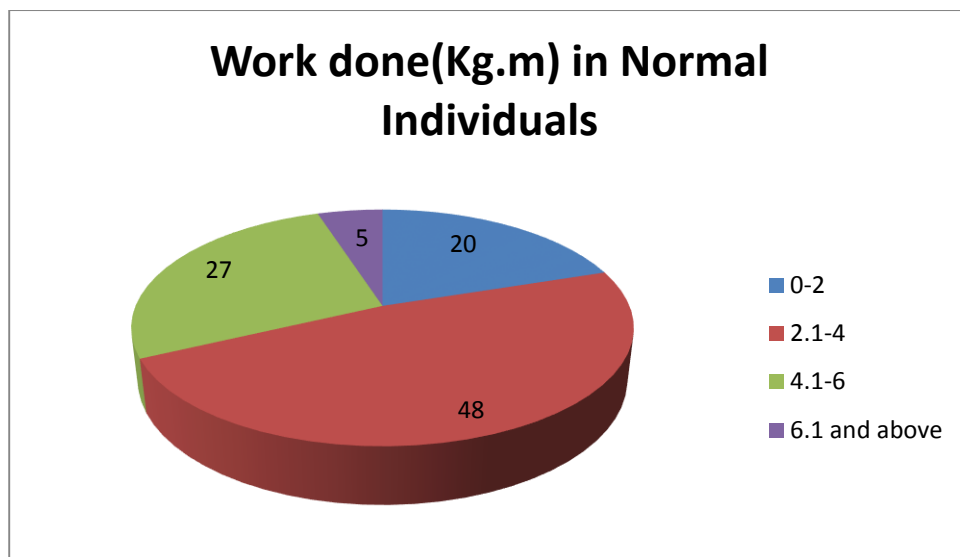


Fig 1. shows work done (Kg.m) in normal individuals

Table 2

Shows group wise distribution of work done (kg.m) in prediabetic individuals

Work Done(kg.m)	N%
0-2	23

2.1-4	58
4.1-6	17
6.1 and above	2

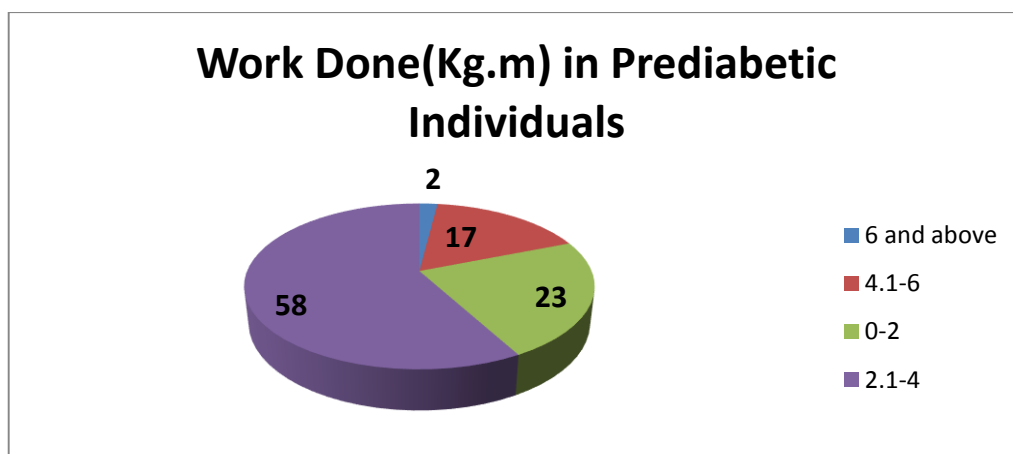


Fig 2. Shows work done (Kg.m) in prediabetic individuals

Table 1 and 2 shows percentage distribution of work done in kg.m in normal and prediabetic individuals across four broad groups of work done i.e. 0-2 kg.m, 2.1-4 kg.m, 4.1-6 kg.m and 6.1 kg.m and above. Among normal individuals, total work done by 20% was between 0-2 kg.m, 48% between 2.1-4 kg.m, 27% between 4.1-6 kg.m and 5% between 6.1 kg.m and above. While among prediabetic individuals, this percentage was 23%, 58%, 17% and 2% respectively.

Table 3

Shows mean age and work done (kg.m) in normal and prediabetic individuals

Characteristics	Normal (N=100)	Prediabetics(N=100)
	Mean $\pm$ SD	Mean $\pm$ SD
Age (years)	39.4 $\pm$ 9	42.6 $\pm$ 11
Work Done(kg.m)	3.4 $\pm$ 1.5	2.9 $\pm$ 1.2

Table 3 shows mean age and work done (kg.m) in normal and prediabetic individuals. The mean age and work done in normal individuals was found to be 39.4 $\pm$ 9 years and 3.4 $\pm$ 1.5 kg.m respectively while in prediabetic individuals it was 42.6 $\pm$ 11 years and 2.9 $\pm$ 1.2 kg.m respectively.

Table 4

Shows age wise distribution of work done(kg.m) among normal individuals

Age(years)	Work done (kg.m)			
	0-2	2.1-4	4.1-6	6.1 and above
24-44	14	36	18	2
45 and above	6	12	9	3
Total	20	48	27	5

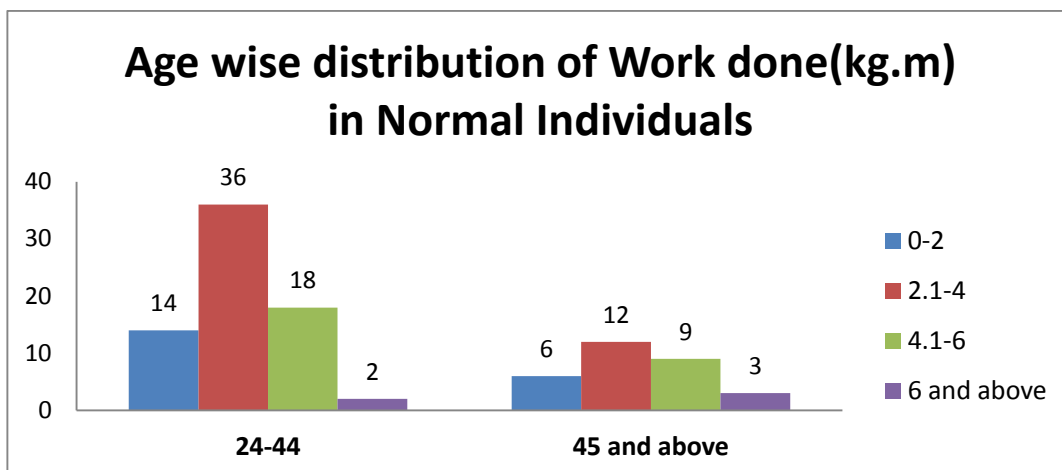


Fig 3. shows age wise distribution of work done (Kg.m) in normal individuals

Table 4 shows age wise distribution of work done (kg.m) among normal individuals across two broad age groups 24-44 years and 45 years and above. In the 24-44 years age group, 14 subjects showed work done between 0-2 kg.m, 36 between 2.1- 4 kg.m, 18 between 4.1-6 kg.m and 2 between 6.1 kg.m and above while in 45 years and above age group, this figure was 6,12, 9 and 3 respectively.

Table 5

Shows age wise distribution of work done (kg.m) among prediabetic individuals

Age(years)	Work done (kg.m)			
	0-2	2.1-4	4.1-6	6.1 and above
24-44	8	29	13	2
45 and above	15	29	4	0
Total	23	58	17	2

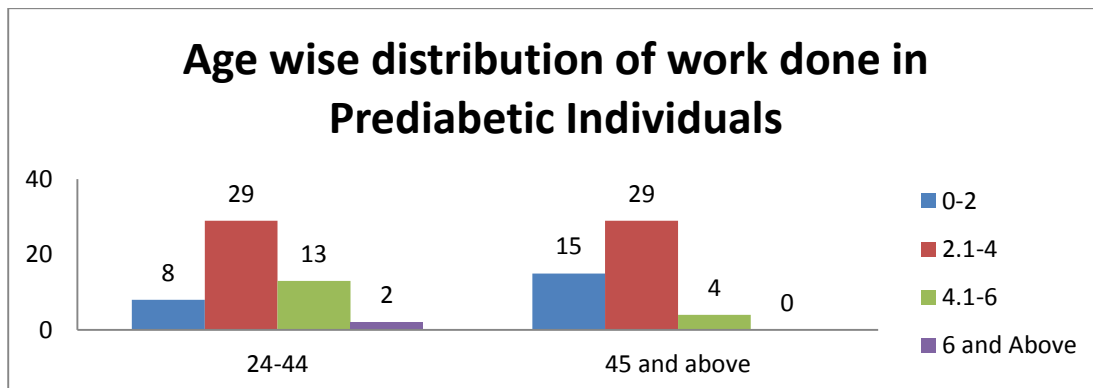


Fig 4. shows age wise distribution of work done (Kg.m) in prediabetic individuals

Table 5 shows age wise distribution of work done (kg.m) among prediabetic individuals across two broad age groups 24-44 years and 45 years and above. In the 24-44 years age group, 8 subjects showed work done between 0-2 kg.m, 29 between 2.1- 4 kg.m, 13 between 4.1-6 kg.m and 2 between 6.1 kg.m and above. While this was found to be 15, 29, 4 and 0 across the four categories of work done in the 45 years and above age group.

Table 6  
Shows gender wise distribution of work done(kg.m) among normal individuals

Gender	Work Done (Kg.m)			
	0-2	2.1-4	4.1-6	6 and above
Female	12	5	0	0
Male	8	43	27	5
Total	20	48	27	5

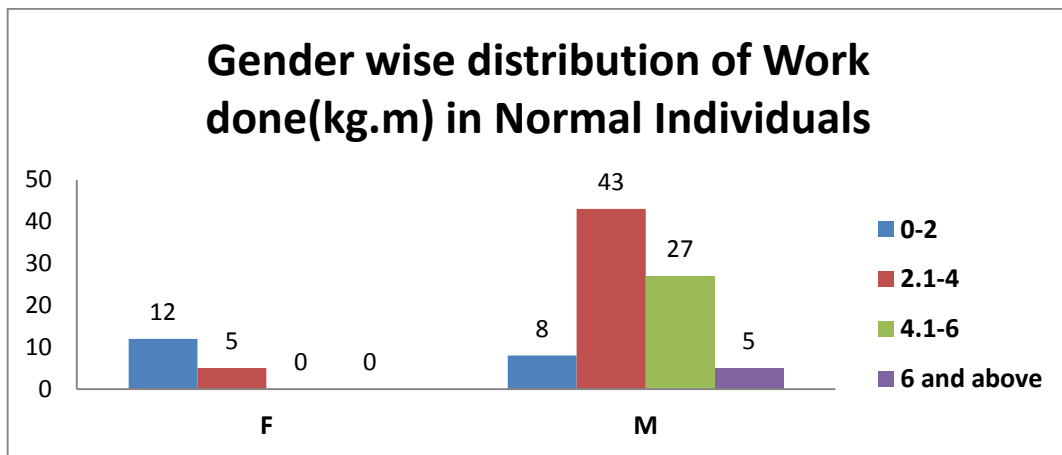


Fig 5. shows gender wise distribution of work done (Kg.m) in normal individuals

Table 6 shows gender wise distribution of work done (kg.m) among normal individuals. Among females, 12 showed work done between 0-2 kg.m, 5 between 2.1-4 kg.m while none of the females could reach a work done level of more than 4 kg.m. In comparison, 8 males showed work done between 0-2 kg.m, 43 between 2.1-4 kg.m, 27 between 4.1-6 kg.m and 5 between 6.1 kg.m and above.

Table 7  
Shows gender wise distribution of work done (kg.m) among prediabetic individuals

Gender	Work Done (Kg.m)			
	0-2	2.1-4	4.1-6	6 and above

Female	16	34	0	0
Male	7	24	17	2
Total	23	58	17	2

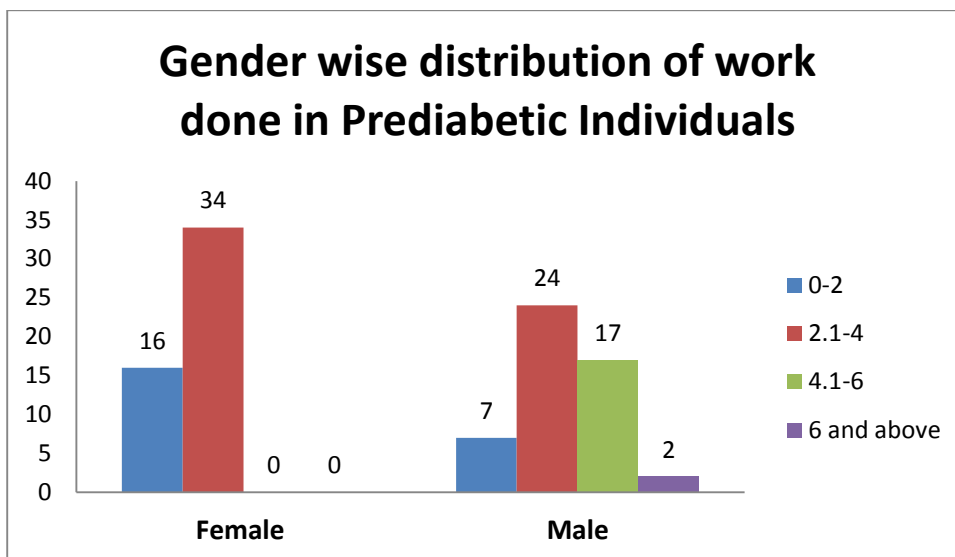


Fig 6. Shows gender wise distribution of work done (Kg.m) in prediabetic individuals

Table 7 shows gender wise distribution of work done (kg.m) among prediabetic individuals. Among females, 16 showed work done between 0-2 kg.m, 34 between 2.1-4 kg.m while none of the females could reach a work done level of more than 4 kg.m. In comparison, 87 males showed work done between 0-2 kg.m, 58 between 2.1-4 kg.m, 17 between 4.1-6 kg.m and 2 between 6.1 kg.m and above.

Table 8

Shows group wise distribution of test for normality for work done (Kg.m) in rediabetic and normal individuals

		Group	N	Mean Rank(U)	Sum of Ranks	p value
Work Done (Kg.m)	Prediabetic Individuals		100	90.26	9025.50	0.00
	Normal Individuals		100	110.75	11074.50	
	Total		200			

\*The test of normality used here is Shapiro-Wilk as the data elements exceed 30. The p value of test is 0.00 which is less than 0.05 and hence we conclude that the data does not follow normal distribution.

From the above table, we find that mean rank of group of normal individuals is higher than the mean rank of group of prediabetic individuals which indicates that work done in normal individuals is higher than work done in prediabetic individuals. The U value of normal individuals is higher (U=110) and p value is less than 0.05 hence we come to a conclusion that Work done in Normal individuals is higher than work done in prediabetic individuals.

## **Discussion**

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<sup>4</sup>. Fatigue is considered to be a reversible physiological state which is characterized by an objective reduction in the performance or its absence resulting from continuous or prolonged activity. It may be classified as acute or chronic fatigue. Acute fatigue is temporary and is relieved with rest. However, chronic fatigue may be pathological and may not be relieved even after rest<sup>5,6,7</sup>. Fatigue is a subjective symptom which lacks measurable concrete signs and is reversible in nature. It is of two types. In central fatigue, a prolonged exercise-induced increase in extracellular serotonin concentrations in several brain regions contributes to the development of fatigue where muscle weakness and tiredness are manifested in the early stage. Peripheral fatigue consists of the inability to sustain a specified force in physical activity or loss of endurance in mental tasks<sup>8</sup>. Muscle fatigue in prediabetics can result because of multiple factors like, emotional stress and anxiety that can progress to full blown diabetes mellitus. Physiological reasons like hyperglycemia that can eventually cause insulin resistance and lifestyle disorders like sedentary behaviour and lack of physical exercise causing obesity and weight control issues. All these factors play a crucial role in causing physical limitations and loss of functional independence and a consequent reduction in work capacity<sup>9</sup>. Mosso's Ergograph is employed to assess the performance of hand and forearm muscle and also to study the phenomenon of fatigue and factors that affect fatigue<sup>10,11</sup>. It has an advantage over other techniques since it helps in isolation of muscle to be used and also makes the conditions of load and registration as close as possible to those in experiments<sup>12</sup>.

It was observed that people with prediabetes had greater performance fatigability of the knee extensors due to contractile mechanisms compared with controls, although less performance fatigability than that of people with Type 2 Diabetes Mellitus<sup>13</sup>. In contradiction, we compared fatigability with normal individuals and found out that greater muscle fatigability was present in flexors of fingers in prediabetics as compared to normal individuals. Probable cause of fatigability in prediabetics has been found to be lack of glucose and oxygen availability to the muscle tissues from blood due to insulin resistance<sup>14</sup>. Georgio Orlando et al <sup>15</sup>, in accordance with our study concluded that muscle fatigability is independent of the quality and mass of the muscle which maybe already present and so is strongly indicative of a possible muscle damage due to high blood sugar levels.

Jonathan Senefeld et al<sup>16</sup> in 2019 also conducted a fatigue test on prediabetics and compared it with controls and Type 2 diabetics and found out that greater muscle fatigability was present in the knee extensors of prediabetics when compared with controls although it was lesser when compared with Diabetics. We also found similar results, although the novelty of our study was that we performed performance fatigue test on flexors of fingers using Mosso's Ergograph. Sucharita Sambashivaiah et al<sup>17</sup> conducted a study to compare muscle function in prediabetic Asian Indians with that of healthy controls and found a significant lower isokinetic and normalized muscle functioning in prediabetic and diabetic individuals as compared to their healthy counterparts which was in accordance to our study as well.

### **Conclusion**

Fatigue is one of the most common problems faced by people with prediabetes and diabetes, especially in elderly patients. Hence, early detection and management of prediabetes will ensure improvement of the quality of life and subsequent progression to diabetes. Regular screening of fatigue, integrated with the screening for other early symptoms of prediabetes like polyphagia, polydipsia, polyuria and blurred vision might become a more complete program for future prevention of prediabetes care and it's subsequent conversion to full blown type 2 diabetes.

**Conflict of Interest:** Nil

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