Effect of Passive Stretch Versus Electrical Stimulation on Blood Glucose Level in Elderly Diabetic Patients

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ABSTRACT

Background: Diabetes is spreading at an alarming rate around the world. According to studies, including exercise into one's regular routine might significantly delay and prevent diabetes. **Purpose** : was to compare between the effect of passive stretching exercises versus electrical stimulation on blood glucose levels in Diabetic patients in their older years. **Subject and Methods**: sixty elderly type 2 diabetic patients of both genders participated in this study. The patient's age ranged from 60 to 75 years. The patients were assigned randomly into to 2 groups. The first group (A): passive stretching group , included 30 patients(29 female and one male) were treated with passive stretching exercises. The second group (B): electrical stimulation group, included 30 patients (29 female and one male) were treated with electrical stimulation. The protocol of treatment was conducted three times per week, for twelve weeks. Venous blood sample was analyzed to determine level of Hemoglobin A1c (HbA1c) before and after twelve weeks. Glucometer was used to measure fasting blood glucose level (FBGL) and post-prandial blood glucose level(PPBGL) after the first session and after twelve weeks of protocol. The functional ability was assessed using the time up and go test (TUG). Fatigue severity scale (FSS) is a nine item questionnaire that is used to determine the degree of tiredness. **Results**: There was a significant decrease in HbA1c, FBGL, PPBGL, TUG and FSS post treatment in the group A and B compared with the pre - treatment. There was non - significant difference between groups post treatment . **Conclusion**: The obtained results suggest that both passive stretching exercises and electrical stimulation have positive effects on blood glucose level , time up and go test and fatigue severity scale in elderly diabetic patients .

Key words: Blood glucose level, Diabetes , Elderly , Electrical stimulation ,Passive stretching

INTRODUCTION

Diabetes is universally recognized as a growing pandemic that has a global impact on nearly every country, age group, and economy**(1).**

Type 1 and Type 2 diabetes can be divided into two groups. Type I diabetes mellitus (T1DM), often known as juvenile diabetes, is characterized by a lack of beta cells and the absence of insulin. Type 2 diabetes mellitus (T2DM) , also known as adult-onset diabetes, is characterized by a key of metabolic issues : Beta cell activity is reduced, resulting in decreased insulin production and peripheral insulin resistance , and increased hepatic glucose production. T2DM affects 90 % to 95 % of people with diabetes **(2)**.

Diabetes mellitus is becoming more prevalent in the older population. People in their later years of life, especially those who have retired, are more likely to choose a sedentary lifestyle, especially if they are confined to the four walls of a retirement home. The most important demographic shift in diabetes prevalence appears to be the increase in the proportion of people over 65 years old **(3)**.

Reduced lifestyle risk factors, including as weight loss and increased physical activity, can assist to prevent or delay the onset of T2DM. Several studies have found that including exercise into one's daily routine might significantly delay and perhaps prevent diabetes **(4,5).**

Circulating blood glucose levels can be regulated by reducing lifestyle risk factors such as muscle stretching, cardiovascular training, yoga, resistance exercises, and so on, as well as improving tissue sensitivity to insulin**(6).**

In all types of diabetes, regular exercise improves glycemic control. In patients with T2DM, insulin resistance is the most prevalent cause of hyperglycemia, and the best way to decrease insulin resistance is to exercise**(7).**

The elasticity of tendons, ligaments, and joint capsules is connected to flexibility, which decreases with age owing to collagen insufficiency. The development of lesions and functional problems is aided by a lack of adequate flexibility**(8).**

Stretching exercises may be more beneficial and effective for type 2 diabetes patients who are unable to engage in regular physical activity due to secondary problems such as neuropathies, hypertension, or limb amputation**(9).**

Due to chronic obesity, orthopaedic difficulties, or severe diabetic complications, many T2DM patients are unable to exercise as recommended (e. g. walking or ergometric exercise). Neuromuscular electrical stimulation (NMES) may be a feasible alternative to conventional exercise for some people. NMES has been demonstrated to improve muscular strength and endurance**(10).**

Neuromuscular Electrical Stimulation (NMES) is a different method of inducing muscle contraction that has been widely utilized in rehabilitation settings to avoid muscle atrophy **(11).** Electrical Stimulation (E. S.) in the lower limb has been shown to significantly lower blood glucose levels in T2DM patients. It has also been proposed as an alternate treatment for T2DM patients who are arthritic, have SCI, or are extremely old **(12).**

The purpose of this research was to compare the effects of passive stretching exercises and electrical stimulation on blood glucose levels in elderly diabetes patients.

SUBJECT AND METHODS

Study design : randomized controlled study

participants : Sixty elderly type 2 diabetic patients had been enrolled in this study; they had been recruited from outpatient clinic of internal medicine department at KASR AL AINY HOSPITAL. They were received their treatment program from November 2020 to April 2021, Patients had been divided into two groups equal in number; the group (A) treated by passive stretching exercises, while the group (B) treated by Electrical stimulation. All subjects fully understood the purpose and methods of the study, which complied with the ethical standards. This study had approval of the Ethics Committee of faculty of physical therapy, Cairo University, NO: P.T.REC/ 012/002921) Egypt . Written informed consent was obtained from each participant. Included and excluded of participants were according to the following criteria.

Inclusion criteria : Sixty elderly type 2 diabetic participants , age ranged from 60-75 years ,All patients have BMI 25 to 29.9 kg/m 2,Duration of diabetes ranged from 4-6 years ,Their HbA1c value between 6.5% -8.5%, They were on oral hypoglycemic drugs at the same dose ,All patients were clinically and medically stable when attending the study

Exclusion criteria : Unstable cardiovascular and chest problems , All other types of diabetes, patients on insulin therapy ,Disorders that affect the HbA1c as chronic renal failure and iron deficient anemia,.Musculoskeletal disorders which may affect their physical ability to do the exercises

Procedure of the study:

A-Measurement procedures

1- Assessment of the level of HbA1c:

The assessment was carried out at the laboratory of KASR AL AINY hospital using Tosoh G8 HPLC analyzer system. Venous blood samples (5 ml) were collected from each patient of the two groups before and after 12 weeks of treatment.

Venous blood samples were collected in the morning at 9 a. m. The samples were collected in anticoagulant free tubes (EDTA K3)

2- Assessment of blood glucose levels:

- The assessment was carried out using Accu - Chek hand held glucometer.
- The Fasting Blood Glucose (FBG) was measured for each patient in the two groups before and after 12 weeks of treatment.
- Two-hours after drinking 250 ml of water containing 75 gm of sugar (**13**).
- Post prandial blood glucose (PBBG) was measured before and after 12 weeks of treatment.
- In the glucometer, place the unused reagent strip. Choose a suitable puncture location and pierce the skin. Squeeze the spot gently to release a big droplet of blood. Fill the strip with the first drop of blood.. **(14)**.

3- Time up and go test (TUG):

The test includes a number of activities, including standing from a seated position , walking , turning , halting, and sitting down, all of which are important for independent mobility (**15**). Any walking aid you use on a regular basis, such as a walker or a quad cane. When the person was seated, the watch was stopped. The total time for the test was determined by the time interval between starting and stopping the watch. The intervals between each press of the start/stop button or the lap button were also recorded by the stopwatch.

4- Fatigue severity scale :

- Each patient had a copy sample that needed to be completed. Each item was read to the patient, who was then asked to pick a number between 1 and 7 to reflect their level of agreement with each item in the FSS
- The strongly disagreement was related to number 1 while the strongly agreement was related to number 7. The method of scoring is recorded by calculating the mean score of each item. The mean score of 4 or more revealed central fatigue **(16)**.

B- Treatment procedure :

1-Passive stretching:

- It was used for group A (stretching group). the muscle was held in a stretched position passively by the therapist for 30 seconds and was repeated four times For each stretch.

- Each repeat was followed by a 15-second rest interval, and the stretches were spaced by at least 30 seconds.
- Before beginning on the left limbs, the right limbs were stretched first, and all four stretches was accomplished before beginning on the left limbs. This was done three times a week for a total period of 12 weeks (**17**).

2- Electrical Stimulation:

- It was used For group B, (electrical stimulation group) EV-906 Digital EMS device will be utilized .
- Participants were subjected to electrical stimulation for 30 minutes. The surface electrode was placed using the vastus and harmstring muscles
- There were four surface electrodes in each muscle. We used a frequency of 20 Hz, a pulse length of 200 seconds, and a duty cycle of 50% in this investigation . The maximum amplitude and current were 80 V and 60 mA, respectively. The exercise regimen lasts 30 minutes (**18,19**).

Data analysis

Descriptive statistics and unpaired t-test were conducted for comparison of subject characteristics between groups. Chi-squared test was conducted for comparison of sex distribution between groups Normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to test the homogeneity between groups. Unpaired t-test was conducted to compare the mean values of HbA1c, FBGL, PPBGL, TUG and FSS between groups. Paired t-test was conducted for comparison between pre and post treatment in each group. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA)

Results:

Subject characteristics:

Table (1) showed the subject characteristics of the group A and B. There was no significant difference between groups in age, BMI and sex distribution ($p > 0.05$).

Table 1. Subject characteristics.

	Group A	Group B	p-value
	Mean ± SD	Mean ± SD	
Age (years)	65.83 ± 5.6	66.8 ± 6.82	0.55
BMI (kg/m²)	27.43 ± 2.72	27.76 ± 2.46	0.62
Sex, N (%)			
Females	29 (97%)	29 (97%)	1
Males	1 (3%)	1 (3%)	

SD, standard deviation; p-value, level of significance

Effect of treatment on HbA1c, FBGL, PPBGL, TUG and FSS:

- *Within group comparison:*

There was a significant decrease in HbA1c, FBGL, PPBGL, TUG and FSS post treatment in the group A and B compared with that pre- treatment ($p < 0.001$). The percent of decrease in HbA1c, FBGL, PPBGL, TUG and FSS in the group A was 8.27, 11.83, 12.36, 30.18 and 20.19% respectively, and that of group B was 7.46, 10.27, 10.27, 29.09 and 23.94% respectively. (table 2).

- ***Between groups comparison:***

There was no significant difference between groups pre-treatment ($p > 0.05$). Comparison between groups post treatment revealed a non- significant difference in HbA1c, FBGL, PPBGL, TUG and FSS ($p > 0.05$). (table 2).

Table 2. Mean HbA1c, FBGL, PPBGL, TUG and FSS pre and post treatment of the group A and B:

	Pre treatment	Post treatment	MD	% of change	t- value	p value
	Mean ± SD	Mean ± SD				
HbA1c (%)						
Group A	7.38 ± 0.79	6.77 ± 0.87	0.61	8.27	7.13	0.001
Group B	7.37 ± 0.81	6.82 ± 0.85	0.55	7.46	8.52	0.001
MD	0.01	-0.05				
t- value	0.01	-0.22				
	p = 0.98	*p = 0.82*				

FBGL (mg/dl)						
Group A	125.36 ± 20.94	110.53 ± 15.65	14.83	11.83	4.83	0.001
Group B	124 ± 18.32	111.26 ± 19	12.74	10.27	4.12	0.001
MD	1.36	-0.73				
t- value	0.26	-0.16				
	p = 0.78	*p = 0.87*				
PPBGL (mg/dl)						
Group A	183.63 ± 37.38	160.93 ± 26.68	22.7	12.36	5.59	0.001
Group B	183.03± 38.5	164.23 ± 27.12	18.8	10.27	3.99	0.001
MD	0.6	-3.3				
t- value	0.06	-0.47				
	p = 0.95	*p = 0.63*				
TUG (sec)						
Group A	16.8 ± 9.51	11.73 ± 6.44	5.07	30.18	8.56	0.001
Group B	17.16 ± 8.5	12.03 ± 6.02	5.13	29.9	7.04	0.001
MD	-0.36	-0.3				
t- value	-0.15	-0.18				
	p = 0.87	*p = 0.85*				
FSS						
Group A	34.96± 13.32	27.9 ± 12.02	7.06	20.19	7.7	0.001
Group B	36.63 ± 13.01	27.86 ± 12.32	8.77	23.94	8.36	0.001
MD	-1.67	0.04				
t- value	-0.49	0.01				
	p = 0.62	*p = 0.99*				

SD, standard deviation; MD, mean difference; p-value, probability value

Discussion:

The goal of this study was to see how passive stretching exercises and electrical stimulation affected blood glucose levels in elderly diabetes patients . This research included sixty elderly type 2 diabetes patients . The patients were divided into two groups at random. Before and after the treatment, all of the patients were assessed using a blood sample analysis of HbA1c, a hand held glucometer, Time up and go test, and a fatigue severity scale.

The HbA1c levels varied from 6.5% to 8%. HbA1c levels of 6.5 percent or below are recommended as the cutoff for diagnosing diabetes; nevertheless, evidence shows that HbA1c levels of more than 8% are linked to poor outcomes, even in groups with high cardiovascular risk **(20).**

The disease extended anywhere from four to six years. According to the findings, elderly people with type 2 diabetes for more than six years have a bad prognosis due to cardiovascular problems (**21**).

According to **Vázquez et al.,** , Obesity has been identified as one of the primary risk factors for poor glycemic control in diabetic patients, thus obese individuals were excluded from this investigation to remove the impact of obesity on diabetic glycemic control **(22).**

The results of the current study showed a considerable improvement in glycemic control, with significant reductions in HbA1c , FBG, and PPBG levels post - treatment in the group A and B compared with that pre- treatment (p < 0 . 001) . The percentage of reduction in HbA1c , FBGL , PPBGL , TUG and FSS in the group A was (8. 27) , (11.83) , (12. 36) . (30. 18) and (20. 19 %) respectively , and that of group B was (7. 46) . (10.27) . (10.27) , (20.9) and (23.94 %) respectively.

This improvement might be attributed to increased heat generation and oxygen consumption in muscles. Because GLUT-4 is integrated into stretched muscles, there is an increase in metabolic activity in these muscles, as well as a decrease in Glycogen content in stretched muscles relative to unstrained muscles, leading in a drop in blood glucose levels **(9).**

Stretching boosts the body's nitric oxide levels by 20%. The inclusion of GLUT-4 is similarly influenced by nitric oxide, making it simpler for it to operate. Stretching has also been found to affect microcirculation, which reduces tissue oxygen exchange. As a result of the ischemia, GLUT-4 translocation into the sarcolemma is enhanced This comes in agreement with (**23).**

The current study came in line with **Nelson et al.,** , who compared two groups to examine the acute effect of twenty minutes of passive stretching on blood sugar levels. The first group was subjected to static stretching, where as the second was subjected to fake stretching, in which individuals adopted stretch postures but no stress was applied to the muscles. Passive stretching was shown to be an effective strategy in lowering blood sugar levels in people with T2DM **(24).**

In another study, patients with type 2 diabetes were compared to the acute effects of active and passive stretching exercises. It was shown that both active and passive skeletal muscle stretching is effective in blood glucose control. The tension created increased the metabolic activity of the muscles, lowering blood glucose levels, thanks to the mechanism described above **(9).**

The findings of this study corroborated those of **Gurudut and Rajan** who investigated the immediate effect of passive stretching versus resistance workouts on blood sugar levels in sedentary T2DM patients. Both passive stretching and resistance activities are beneficial in lowering PPBG levels in T2DM patients, according to the study, and should be prescribed for individuals who have trouble managing the postprandial rise**(25).**

Park, conducted a study to determine the long-term effects of passive static stretching on blood glucose levels in patients with T2DM, and found that HbA1c decreased significantly after 8 weeks of passive stretching exercises, leading to conclude that passive static stretching of the skeletal muscles could be an alternative to exercise to assist diabetes individuals in controlling their blood glucose levels **(23).**

The Time up and go (TUG) test was used to measure the functional mobility of the patients in all groups in the current study . According to the findings of this study, there was a substantial drop in The time interval between the start and stop points determined the total duration for the test, indicating that the participant's functional skills improved.

According to **Oliveira et al .**there is a link between hyperglycemia and decreased mobility , with an increased risk of falling even in younger patients and those who have had the illness for a shorter time**(26).**

Among all studies that reported glucose utilization during NMES , reported increased glucose utilization during NMES regardless of stimulation frequency (low or high) and NMES intensity. Effectiveness of NMES glucose utilization was evident in healthy as well as population with T2DM and SCI **(27).**

According to **Arsianti et al.,** Proved that a low current supplied to the muscles of the lower extremities through a surface electrode stimulates the neuromuscular junction, causing muscle contraction. When muscles contract , the sensitivity of insulin receptors in the muscle increases , causing the activation of glucose transporting receptors. As a result, blood glucose levels will decrease**(19)**.

The results of this study are supported by a Study conducted by **Arsianti et al**, reveal that ES has a substantial effect on reducing blood glucose levels in T2DM patients in the lower leg. This alternate approach is recommended for T2DM individuals who are rheumatic, have SCI, or are very elderly**(12).**

Among all studies that reported glucose utilization during NMES , reported increased glucose utilization during NMES regardless of stimulation frequency (low or high) and NMES intensity. Effectiveness of NMES glucose utilization was evident in healthy as well as population with T2DM and SCI **(27).**

Although our findings strongly suggest the effectiveness of NMES to improve glycemic control and insulin sensitivity, a specific recommendation of NMES protocol has not been established. Lack of randomized control trials along with varied study population makes this challenging to determine effective recommendation (**27**). which indicates that both low and high intensity NMES with varied frequency has been effective in acute increase in glucose utilization as well as improving insulin sensitivity.

According to **Joubert et al**, It is important to note that many patients complain of discomfort , pain and limitations on subjective tolerance particularly under high frequency and high intensity stimulation. While considering NMES protocol, it is important to consider safety and comfort of the individuals, and the target population (e. g. insulin resistant or having physical limitations to perform physical activities **(28)**.

According to **Jabbour et al.,** in a middle-aged population with T2DM, observed a substantial reduction in glucose concentrations following an acute (1 hour) session of low frequency NMES (8 Hz), which was found to be acceptable by all subjects **(29)**.

These findings are also corroborated by **Joubert et al.,**who demonstrated a substantial increase in glucose absorption evaluated by the hyperinsulinemic euglycemic clamp in a group with T2DM following a single session of 25 minutes of low frequency (35 Hz) of NMES **(28) .**

Participants in our research were given 30 minutes of electrical stimulation at a frequency of 20 Hz , a pulse duration of 200 seconds, and a 50% duty cycle. The maximum amplitude and current are 80 V and 60 mA , respectively. The exercise routine lasts 30 minutes and results in a substantial reduction in blood glucose levels.

According to Sanchez**. ,** Chronic high frequency protocol was changes to glucose uptake and it was noted that participants were unable to tolerate NMES intensities above 40 mA (approximately 10% of maximum voluntary contraction . Poor tolerability is often explained as a limiting factor in many studies **(27)**.

The findings of this study opposed those of a previous study (**Arsianti et al .,** Both electrical stimulation and passive stretching can be used to control blood glucose levels in sedentary patients with chronic illnesses, people with physical limitations , and people who lack motivation to exercise , but electrical stimulation is more effective than passive stretching at lowering blood glucose levels **(12).**

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