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Active versus Passive Stretching Exercises on Blood Glucose and Functional Capacity in Elderly Diabetic Patients: Comparative Study.

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Abstract:
Background: *The prevalence of diabetes is rapidly rising all over the globe at an alarming rate. studies have shown that lifestyle changes that include exercise can significantly delay and possibly prevent diabetes .*
Aim of the Study: *To compare the effect of active versus passive stretching exercises on blood glucose level in elderly diabetic patients.*
Material and Methods: *Fifty elderly type 2 diabetic men participated in this study. The patient's age ranged from 60 to 70 years. The patients were divided randomly into to 3 groups. The first group (A) included 20 patients were treated with active stretching exercises. The second group (B) included 20 patients were treated with passive stretching exercises. The third group (C) was the control which included 10 patients received no treatment. The stretching exercises were 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 post-prandial blood glucose (PPBG) acutely after the first session and after twelve weeks. Six minute walking test (6MWT) was preformed to assess the functional capacity.*
Results: *there were a non-significant difference in the mean values of all variables in all groups pre study. At the end of the study there was a significant decrease in mean values of HbA1c, Acute and chronic post-prandial blood glucose levels in groups A and B mean and significant increase in distance walked in 6 min walk test. In the control group (C) there was a non-significant change in all variables except the acute post prandial blood level which decreased significally. In between groups there was a non-significant difference in the mean values of all variables between group A and B with significant difference between both of them and group C (**$p<0.05$**).*
Conclusion: *The obtained results suggest that both Active and passive stretching exercises have positive effects on blood glucose level and functional capacity in elderly diabetic patients.*
Keywords: *Diabetes, Elderly, Active stretching, Passive stretching, Blood glucose.*

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I. Introduction

Diabetes is a complex, chronic illness requiring continuous medical care with multifactorial risk-reduction strategies beyond glycemic control**(1).** Diabetes can be classified into two categories namely, type 1 and type 2. Type 1diabetes mellitus (T1DM) is also known as juvenile diabetes and it is a disease of absolute insulin deficiency characterized by beta cell failure. Type 2 diabetes mellitus (T2DM) is also called as adult-onset diabetes, which involves relative insulin deficiency and is characterized by a combination of three main metabolic problems; decreased beta cell function with reduced insulin production, insulin resistance in the peripheral tissues and increased hepatic glucose production. Among the people with diabetes, 90% to 95% have T2DM**(2).**

There is increased prevalence of diabetes mellitus among the elderly. In the later years of one's life especially after retirement, they are succumb to sedentary lifestyle especially being confined to the four corners of a retirement home. The most important demographic change to diabetes prevalence across the world appears to be the increase in the proportion of people over 65 years of age**(3).**

It is possible to prevent or delay the onset of T2DM by reducing lifestyle risk factors through moderate weight loss and increased physical activity. Several studies have shown that lifestyle changes that include exercise can significantly delay and possibly prevent diabetes**(4, 5).**

It is generally agreed that Regular exercise improves glycemic control in all forms of diabetes **(6).** Physical activities such as muscle stretching, aerobic training, yoga, resistance exercises, etc. by improving tissue sensitivity to insulin **(7).** During exercise, glucose uptake in striated muscles increases remarkably thus strategically reducing glucose levels in the body **(8, 9).**

Static stretching involves holding a muscle in a challenging but comfortable position for 30 seconds without moving the extremity during the stretch. It can be performed either actively or passively. Active stretching is performed by the subject independently whereas passive stretching involves a stretch applies by the therapist or any other external force **(9).**

Nelson et al. conducted a study on effectiveness of stretching on blood glucose in subjects with diabetics and subjects those who are at risk and the author concluded that twenty minutes of passive stretching lowers glucose levels in an at risk population**(10).** The diabetes patients could realise better blood glucose control and health at a substantial financial saving if a stretching program (either passive or active) under the supervision of a physical therapist or other trained personnel was established. It is a known fact that stretching daily for 20-40 minutes has the metabolic rate similar to the rate estimated for walking 40 minutes**(11).**

Solomen et al. compared between Passive and active stretching on immediate blood glucose in subjects with T2DM and conducted that both active and passive stretching of skeletal muscle is effective in blood glucose control. However passive stretching was better than active stretching in reducing the blood sugar level**(9).**

Thus there is a need to determine which of these stretches would actually benefit in an efficient and effective way to reduce the blood glucose level and improving functional capacity. Thus the objective of the study was to compare the immediate and long term effect of active and passive stretching exercises in lowering blood glucose level in elderly type 2 diabetic patients.

II. Methods

Patients and Methods:

A randomized controlled comparative study which was conducted on fifty elderly type 2 diabetic men. Their age ranged from 60 to 70 years. All patients were diagnosed with T2DM with HbA1c value from 6.5% to8.0%. They were on oral hypoglycemic drugs at the same dose. Duration of diabetes from 4 to 6 years. All patients were clinically and medically stable when attending the study. Patients with unstable cardiovascular problems or with musculoskeletal diseases which may affect their physical activity or patients on insulin therapy were excluded.

The patients were assigned randomly into three groups. The first group (A) included 20 patients with mean of age (65.35 ± 2.9 years) and BMI (25.8± 2.25 kg/m^2) were treated with active stretching exercises. The second group (B) included 20 patients with mean of age (64.6 ± 2.9 years) and BMI (26.17± 2.12 kg/m2) were treated with passive stretching exercises. The third group (C) was the control which included 10 patients with mean of age (64.9 ± 2.51 years) and BMI (26.18± 1.97 kg/m2) received no treatment. The stretching exercises were conducted three times per week, for twelve weeks. This study was conducted in the outpatient clinic of internal medicine department at El Mahalla Al Kobra general hospital in the period from February to august 2018. Patients signed on informed consent and the study was approved by the Ethics Committee of the faculty of physical therapy before beginning of the study to insure complete satisfaction.

Study design: A randomized controlled comparative study.

Instrumentation

I) for evaluation:

All the following measured variables had taken place was carried out at the laboratory of El Mahalla Al Kobra general hospital.

1- **Laboratory VARIANT™ α TURBO system:** It was used to measure HbA1c.
2- **Hand held glucometer:** It was used to measure PPBG.
3- **6MWT**: It was used to evaluate the functional capacity.

Procedures:

A- Assessment procedures:

1- Assessment of the level of HbA1c:

The assessment was carried out at the laboratory of El Mahalla Al Kobra general hospital using VARIANT™ α TURBO system . Venous blood samples (5 ml) were collected from each patient of the three groups before and after 12 weeks of treatment. The patients in the control group who didn't receive treatment sessions also were measured at the same time. Venous blood samples were collected at 8 a.m. for all patients.

2- Assessment of the blood glucose levels:

- **Acute PPBG:**

The assessment was carried out using Accu-Chek hand held glucometer. PPBG was measured for each patient in the three groups. The patients in the control group who didn't receive treatment session also were measured at the same time. Two- hours after drinking 250 ml of water containing 75 gm of sugar, blood glucose was immediately measured before the beginning and immediately after the end of the first session.

- **Chronic PPBG:**

The assessment was carried out using Accu-Chek hand held glucometer. PPBG was measured for each patient in the three groups. The patients in the control group who didn't receive treatment session also was measured at the same time. The post prandial blood glucose was measured before and after 12 weeks of treatment.

3- Assessment of the functional capacity:

6MWT was conducted for each patient before and after 12 weeks of treatment. Each patient was instructed to wear comfortable clothing and shoes. The patients rested in a chair located near the starting position, for at least 10 minutes before the test started. During that time, they were checked for contraindications. Each patient was asked to walk as far as possible for 6 minutes. At the end of the 6 minutes, The distance walked in meter was calculated and recorded**(12).**

B- Treatment procedures:

1- Active stretching:

It was used for group A. The interventions was carried out for the following muscles: Trapezius, Biceps brachii, Triceps brachii, Pectoralis Major, Quadriceps, Hamstrings, Calf muscles and Glutei. participants performed a 40 minutes of active stretching exercises in form of hold–relax technique for the eight muscles determined before. The muscle was first lengthened to the point of limitation or to the extent that was comfortable for the patient. The patient then performed a pre stretch, end-range, isometric contraction (for 5 to 10 seconds) followed by voluntary relaxation of the tight muscle. The limb is then passively moved into the new range as the range-limiting muscle is elongated. For each stretch, the muscle was held in a stretched position for 30 seconds and was repeated four times. A 15 second relaxation period separated each repeat, and a minimum 30 seconds separated the different stretches. For those stretches the right limbs were stretched first, and all the four stretches were completed before starting on the left limbs. This was done three days per week for 12 weeks**(10).**

2- Passive stretching:

It was used for group B. participants received a 40 minutes of passive stretching exercises for the eight muscles determined before (Trapezius, Biceps brachii, Triceps brachii, Pectoralis Major, Quadriceps, Hamstrings, Calf muscles and Glutei). For each stretch, the muscle was held in a stretched position passively by the therapist for 30 seconds and was repeated four times. A 15 second relaxation period separated each repeat, and a minimum 30 seconds separated the different stretches. For those stretches the right limbs were stretched first, before starting on the left limbs, and all the four stretches will be completed before starting on the left limbs. This was done three days per week for 12 weeks**(10).**

Statistical analyses were performed using SPSS software (version 20). Descriptive statistics and paired T-test to compare between pre and post treatment results for each group and ANOVA test to compare results between groups. All statistically significant differences were determined with confidence interval of 95% and thus at $P<0.05$.

III. Results

Baseline data:

In the present study as shown in (Table 1), there were non-significant ($P\geq0.05$) difference in age, BMI and the duration of diabetes between all groups. The mean of age was 65.35 ±2.90, 64.60 ±2.90 and 64.90± 2.51 for group A, B and C respectively. The mean of BMI was 25.8± 2.25, 26.17± 2.12 and 26.18± 1.97 for group A, B and C respectively. The mean of the duration of diabetes was 4.46± 1.37, 5.36± 1.51 and 5.52± 1.63 for group A, B and C respectively.

The effect on HbA1c (mean ± SD):

The obtained data presented in (Table 2) revealed there was no significant difference in the HbA1c level pre-treatment between all groups. After the intervention, HbA1c level decreased significantly in group A and B. However, There was no significant difference in group C.

Noteworthy, the obtained data presented in (Table 3) revealed post-treatment HbA1c extremely (P < 0.0001) decreased from 7.41±0.59 to 6.65±0.47 in group A and extremely decreased (P < 0.0001) from 7.37±0.60 to 6.78±0.53 in group B. However, In group C HbA1c showed no significant change (P = 0.864) from 7.40±0.516 to 7.41±0.636. Comparison of post treatment HbA1c between groups on the basis of ANOVA test as shown in (table 4) revealed a significant difference(P = .002). On the basis of Scheffe test (table 5), although there was no significant difference between A and B groups (P = .762), a significant difference was found between A and C groups (P = .003) and also between Band C groups(P = .015).

Acute PBBG response (mean ± SD):

The obtained data presented in (Table 1) revealed there was no significant difference in the PBBG level pre-treatment between all groups. After the intervention, acute PBBG level decreased significantly in all groups.

Noteworthy, the obtained data presented in (Table 2) revealed acute post-treatment PBBG extremely (P < 0.0001) decreased from 239.6±27.5 to 196.1±28.8 in group A and extremely decreased (P < 0.0001) from 235.1±34.02 to 194.65±29.4 in group B. In group C, PBBG showed a significant decrease (P < 0.001) from 243±26.9 to 246.3±30.3. Comparison of acute post treatment PBBG between groups on the basis of ANOVA test as shown in (table 3) revealed a significant difference(P = .009). On the basis of Scheffe test (table 5), although there was no significant difference between A and B groups(P = .986), a significant difference was found between A and C groups (P = .023) and also between Band C groups(P = .016).

Chronic PBBG response (mean ± SD):

The obtained data presented in (Table 2) revealed there was no significant difference in the PBBG level pre-treatment between all groups. After the intervention, Chronic PBBG level decreased significantly in group A and B. However, There was no significant difference in group C.

Noteworthy, the obtained data presented in (Table 3) revealed chronic post-treatment PBBG extremely (P < 0.0001) decreased from 239.6±27.5 to 192±18.9 in group A and extremely decreased (P < 0.0001) from 235.1±34.02 to 204.8±21.5 in group B. In group C, PBBG showed no significant change (P = 0.398) from 243±26.9 to 246.3±30.3. Comparison of Chronic post treatment PBBG between groups on the basis of ANOVA test as shown in (table 4) revealed a significant difference(P < 0.001). On the basis of Scheffe test(table 5), although there was no significant difference between A and B groups(P = .209), a significant difference was found between A and C groups (P < 0.001) and also between Band C groups(P < 0.001).

6MWT:

The obtained data presented in (Table 2) revealed there was no significant difference in the distance walked in 6MWT pre-treatment between all groups. After the intervention, the distance walked in 6MWT increased significantly in group A and B. However, There was no significant difference in group C.

Noteworthy, the obtained data presented in (Table 3) revealed the distance walked in 6MWT post-treatment extremely (P < 0.0001) increased from 299.5±40.1 to 356.9±38.8 in group A and extremely increased (P < 0.001) from 314.7±49.9±34.02 to 350.4±48 in group B. In group C, there was no significant change (P = 0.398) from 289.7±41.7 to 296.5±43.1. Comparison of the distance walked in 6MWT post treatment between groups on the basis of ANOVA test as shown in (table 4) revealed a significant difference((P = .002)). On the basis of Scheffe test (table 5), although there was no significant difference between A and B groups(P = .895), a significant difference was found between A and C groups (P = .003) and also between Band C groups (P = .010).

Table 1: Baseline characteristics of the patients

Variable	A	B	C	P-value
Age(yr)	65.35± 2.90	64.60± 2.90	64.90± 2.51	0.705
BMI(kg/m2)	25.8± 2.25	26.17± 2.12	26.18± 1.97	0.338
Duration of diabetes(yr)	4.46± 1.37	5.36± 1.51	5.52± 1.63	0.086

Values are means ± SD.

A: active stretching group; B: passive stretching group; C: control group; BMI: body mass index.

Table 3: Pre-post data within groups:

Variable		A	P-value	B	P-value	C	P-value
HbA1c	Pre	7.41±0.596	<0.001*	7.37±0.603	<0.001*	7.40±0.51	0.864
	Post	6.65±0.475		6.78±0.538		7.41±0.636	
PPBG (Acute effect)	Pre	239.6±27.5	<0.001*	235.1±34.02	<0.001*	243±26.9	<0.001*
	Post	196.1±28.8		194.65±29.4		227.6±24.7	
PPBG (Chronic effect)	Pre	239.6±27.5	<0.001*	235.1±34.02	<0.001*	243±26.9	0.398
	Post	192±18.9		204.8±21.5		246.3±30.3	
6MWT	Pre	299.5±40.1	<0.001*	314.7±49.9	<0.001*	289.7±41.7	0.338
	Post	356.9±38.8		350.4±48		296.5±43.1	

values are means±SD
A: active stretching group; B: passive stretching group; C: control group; HbA1c: glycosylated hemoglobin; PPBG: post-prandial blood glucose; 6MWT: Six minute walking test .*P<0.05, statistical significance.

Table 2: Pre treatment data within groups:

Variable	A	B	C	P-value
HbA1c(%)	7.41±0.59	7.37±0.60	7.40±0.51	0.970
PPBG (mg/dl)	239.6± 27.5	235.1± 34.0	243± 26.9	0.779
6MWT(m)	299.5± 40.1	314.7± 49.9	289.7± 41.7	0.314

Values are means ± SD.
A: active stretching group; B: passive stretching group; C: control group; HbA1c: glycosylated hemoglobin; PPBG: post-prandial blood glucose; 6MWT: Six minute walking test .

Table 4: ANOVA test

Variable	F	Sig.
HbA1c	6.976	.002*
PPBG (Acute effect)	5.168	.009*
PPBG (Chronic effect)	19.577	.000*
6MWT	6.991	.002*

*P<0.05, statistical significance.

Table 5: Scheffe test

		HbA1c	PPBG (Acute effect)	PPBG (Chronic effect)	6MWT
A	B	.762	.986	.209	.895
	C	.003*	.023*	.000*	.003*
B	A	.762	.986	.209	.895
	C	.015*	.016*	.000*	.010*
C	A	.003*	.023*	.000*	.003*
	B	.015*	.016*	.000*	.010*

*P<0.05, statistical significance.

IV. Discussion

The present study was conducted to compare between the effect of active and passive stretching exercises on blood glucose levels in elderly diabetic patients. The results of the present study proved that there was a significant improvement in glycemic control including significant reduction of HbA1c, Acute and chronic PBBG in the active (A) and passive (B) stretching groups with no significant difference between both groups.

This was in accordance with the study done by Nelson et al who analyzed the effect of twenty minutes passive stretching on diabetic patients and concluded that passive static stretching of the skeletal muscles may be an alternative to exercise to help lower blood glucose levels**(10).**

According to a study by Park, passive stretching increases heat production and oxygen consumption in muscles. This leads to an increase in the metabolic activity in these muscles thus causing reduction in the blood glucose level**(13).**

Another study was done by Solomen et al**. (9)** to compare the immediate effects of active and passive stretching exercises in T2DM patients concluded that passive stretching yielded better results than active stretching. This was probably due to the maintenance of a constant tension throughout the passive stretch as compared to the active stretch**.**

There are several possible mechanisms as to why blood glucose level has decreased following both active and passive stretching. According to Masahiro Iwata**(14)** mechanical stimuli such as stretch increase glucose transport and glycogen metabolism in skeletal muscle. The effects of stretch-stimulated glucose transport are independent of the insulin-signalling pathway. Glycogen content of stretched muscles decreases in compared to unstretched muscles . According to a review by Dohm**(15)**, glucose transport into the skeletal muscles is primarily mediated by a glucose transport protein, GLUT-4; accordingly, exercise can increase GLUT-4 levels in the skeletal muscles**.** Furthermore, increased metabolic activity accompanying passive muscle stretching is related to the GLUT-4 activation pathway. Therefore, passive muscle stretching could induce the incorporation of GLUT-4 into the stretched skeletal muscles**(15, 16).**

The results of the present study contradicted with the finding of Fairrow**(17)** who reported that active static stretching in people with T2DM, pre-diabetes, or those at risk for diabetes does not significantly lower blood glucose levels in comparison to doing nothing. The discrepancy may be attributed to the small sample size and the short duration of the physical therapy intervention of Fairrow study.

In the current study 6MWT was used to assess the functional capacity of the patients in all groups pre and post treatment. The results of this study showed that there was significant increase in the distance walked in six minutes in both active and passive stretching groups, with no significant difference between them.

The results of the present study agreed with the results of Gajdosik et al and Stanziano who revealed that stretching exercises improve the functional capacity in diabetic patients.The improvement may be attributed to a series of mechanisms may be associated with the improvement in the levels of muscle strength, changes in the elastic properties of the musculoskeletal system, such as viscosity of the muscle-tendon unit, which may allow a better reuse of elastic energy during the stretch-shortening muscle cycle and consequent better reuse of elastic energy, promoting greater levels of muscular strength. **(18, 19)**.

The results of the present study disagreed with the results of Stathokostas et al**(20)** who revealed that stretching improves flexibility outcomes, but not necessarily functional outcome measures. The discrepancy between results of the current study and results of Stathokostas et al. study may be due to difference of as such, a specific prescription of how long to hold a stretch, how many repetitions of each stretch to conduct, and the type of stretches to do, is not determinable at this point.

The present study had several limitations. The study was limited to males which were only available. Due to the time factor, immediate PPBG decreased acutely in the control group as a normal physiological response. The diet of the subjects was not controlled. The sample size was insufficient to generalize the results to all patients with T2DM.

A prospective study could be taken up to evaluate the long term effects of the exercises specifically during the fasting period. This study can also be repeated by using a different target population such as patients with hypertension or other metabolic conditions with comparisons of different forms of exercises as aerobic or resisted exercises.

V. Conclusion

Based on the findings of the current study, it is concluded that both Active and passive stretching exercises improve glycemic control and functional capacity in elderly diabetic patients with no difference between them. So passive and active stretching are effective therapeutic maneuvers for care of old diabetics.

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