

How to Cite:

Elwahaab, H. A. A., Gmal Eldin, M. Y., Abdelhakiem, N. M., & Mahmoud, T. H. (2021). Effect of dynamic exercise of upper limb versus lower limb on diabetic elderly women. *International Journal of Health Sciences*, 5(S1), 815–826. <https://doi.org/10.53730/ijhs.v5nS1.14424>

Effect of dynamic exercise of upper limb versus lower limb on diabetic elderly women

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Abstract---Background: Complications from type II diabetes mellitus (DM) are especially serious for older people. Objective: The purpose of this study is to evaluate the efficacy of upper limb ergometry against lower limb ergometry in reducing blood glucose levels in elderly women. Materials and methods: Forty female patients, aged 60-70, with type II DM took part in the study. Pre-treatment, the mean \pm SD values for blood glucose were 279.9 ± 60.99 mg/dl in group A while in group B they were 281.7 ± 38.69 mg/dl. Two groups of involving 20 subjects each were used in this study. Group (A) received upper-extremity ergometry activities, whereas Group (B) received lower-extremity ergometry exercises. Prior to and following three sessions per week for three months, blood glucose levels were monitored. Results: Upper extremity ergometry exercise is more effective than lower extremity ergometry exercise in reducing blood glucose level. Improvement in blood sugar levels was higher (21.04%) in group (A) than in group (B) (12.26%). Conclusion: Blood glucose levels in elderly women were shown to be more effectively controlled with upper extremity ergometry exercise than with lower extremity exercise.

Keywords---Blood glucose level, Ergometry exercise, Elderly women.

Introduction

In the elderly, type II DM is prevalent and can have severe complications¹. Various individuals and even various organs are affected by the aging process in different manners. Most geriatricians agree that aging results from a combination of factors present throughout one's life. Factors like as genetics, environment, culture, diet, physical activity, leisure time, and medical history are just a few of the many that can affect an individual's health². Exactly how or why individuals change as they become older remains unclear. Some hypotheses attribute aging to continuous exposure to UV light, general wear and tear, or metabolic by-products. A few theories explain aging as a genetically driven process^{3,4}.

Despite risk for having diabetes increases with age, it appears to level off or even decrease after age 85 due to underlying genetic as well as environmental influences that are specific for every individual⁵. Insulin resistance in muscle develops regardless of the presence of obesity in some elderly people due to -cell dysfunction and insufficiency, which plays a larger role in the pathogenesis of diabetes in elderly individuals than in younger persons^{6,7}. Diabetes incidence varies with different measures. Diabetes affects at least 25% of those over the age of 65⁸, and can only be diagnosed with a 2 h oral glucose tolerance test (111 mmol/L) for 58% of cases.^{9,10} There is no consensus that an oral glucose tolerance test is the best way to detect diabetes. Testing for HbA1c concentration is advised because it is simple (12-hour fasting is not necessary), and it may identify 14.5 percent of undiagnosed cases (6.5 percent, or 48 millimoles per mol) of diabetes¹¹; however, when fasting plasma glucose concentration (7 millimoles per liter) testing is also performed, detection rises to 42.1 percent. Consequently, almost all of persons with diabetes aged 65 and up remain undiagnosed despite utilizing both HbA1c as well as fasting plasma glucose to confirm the diagnosis. The delay in preventing the progression of diabetes and its complications caused by glucose disequilibrium can frequently be the result of the low identification in older persons with these easily accessible diagnostic procedures. As a result, significant insulin resistance with obesity may be a more prominent component in younger patients due to differences in the pathophysiology of diabetes in comparison with to those who are older ages. The variety of the elderly population as well as their underlying diseases necessitates an increased concentration on individualized care. The majority of physicians agree that healthy elderly people, like healthy children and young adults, should be screened for diabetes. If prediabetes is detected, a patient-specific lifestyle intervention may avoid the onset of diabetes as well as its micro- and macrovascular complications. Somebody with major functional impairments or Alzheimer's disease would not be a good candidate for this type of test¹².

Disorders in insulin secretion, action, or both cause the elevated blood glucose levels seen by individuals with DM ^{13,14}. Insulin, a hormone produced by the pancreas, normally regulates blood glucose levels by reducing their concentration in the blood. Although it is possible to keep diabetes under control, it remains a lifelong condition¹⁵.

During exercise, the muscles need more glucose than usual, and this increase is proportional to the amount of work being done. despite this, the hormones

glucagon as well as catecholamine, which reduce insulin function, are released in response to strenuous physical activity. Continuation of an exercise program has been shown to normalize abnormal lipid metabolism in addition to increase insulin sensitivity among individuals with impaired glucose tolerance as well as type II diabetes¹⁶.

In accordance with these findings, the American Diabetes Association (ADA) suggests that patients with type II diabetes participate in at least 150 minutes of weekly aerobic activity with intermittent periods of moderate intensity. Patients with diabetes should exercise at a moderate intensity, between 50% as well as 75% of their maximal heart rate¹⁷.

Aerobic exercise effects

Blood glucose levels in non-diabetic individuals do not alter during moderate-intensity exercise until the activity lasts for an extended period of time and causes a depletion of glycogen stores in the muscles. Moderate exercise has been shown to reduce blood glucose levels among individuals with type II DM by increasing muscle glucose use relative to hepatic glucose synthesis¹⁸. Exercise-induced hypoglycemia is uncommon in individuals who are not using insulin or insulin secretagogues, even with extended exercise, because plasma insulin levels naturally decline. The length, intensity, and diet consumed after a single session of aerobic exercise all influence the extent to which that session improves insulin action as well as glucose tolerance for longer than 24 hours but shorter than 72 hours¹⁹. Moderate aerobic exercise produces the same benefits whether it is completed in a single long session or several shorter ones²⁰.

Materials & Methods

The purpose of this study, which was carried out at the Deraya University outpatient clinics, was to compare the impact of upper- and lower-extremity exercises on blood glucose levels in old women with Type II DM.

Participants

Forty diabetics elderly women were selected from Minia University Hospital according to the following criteria: Age ranged from 60 to 70 age. The patients were chosen after physicians diagnosed them with Type II DM both clinically and through laboratory testing. All patients have been diagnosed with moderate hyperglycemia as determined by a plasma glucose level of 200 mg/dl (11.1 mmol/l) after two hours of an oral glucose tolerance test (OGTT), each of them had diabetes for more than 10 years, and all patients are currently taking an oral hypoglycemic medication, The blood glucose levels of all patients are between 180 and 400 mg/dl. These patients were excluded in the study because they met one of the following set of criteria: Diabetic patients with neuropathy, Liver diseases, heart diseases, lung diseases, Patients with cancer, Patients with renal failure, Patients with severe hypertension, hemiplegia, Parkinson's disease, muscle spasms, and fractures or dislocations in the limbs, as well as those with difficulties with balance.

Instrumentation

(A) Standard Weight and height scales that was used to measure the weight and height of each patient to exclude any obese patients. Mercurial sphygmomanometer and stethoscope for measuring blood pressure and consequently select subjects with normal blood pressure (according to physician guidance) Disposable plastic syringe used for blood sample taking. Tubes for blood sample collection. Automated clinical chemistry analyzer (Micro lab 200), made in Germany that was used for measuring blood glucose level.

(B) Exercise Equipment:

1. Upper limb ergometer (Rodby) supplied with electronic digital display of time, speed, distance and heart rate monitor that was used for conducting aerobic exercise in group A.
2. Lower limb ergometer (Rodby) supplied with electronic digital display of time, speed, distance and heart rate monitor was used for conducting aerobic exercise in group B.

Procedures

1. All patients were examined by the physician to ensure that they met the inclusion criteria, before beginning the study, all participants received a thorough explanation of the process, including any potential hazards or discomforts.
2. A consent form was signed by all patients who agreed to take part in the trial. The antecubital vein was used to collect blood samples before and after the exercise session. Blood sugar levels were checked prior to and following every session, 3 times a week for 3 months²¹. Subjects were able to perform arm and leg cycling in a comfortable position as both ergometers must be within the level of body position.

Exercises prescription

Group A Involved 20 elderly diabetic women patients, each of them performed a 35 minutes of arm ergometer exercises distributed into 3 phases: warming up phase for 10 minutes, active phase for 20 minutes at 50% to 75% of the maximum predicted heart rate and cooling down phase for 5 minutes immediately after two hours postprandial condition and the blood sample was collected from antecubital vein immediately before and after exercise session.

Group B This group involved 20 women diabetic female patients, each of them performed stationary lower limb cycle ergometer exercises for 35 minutes divided into three phases: warming up phase for 10 minutes, active phase for 20 minutes within 50% to 75% of the maximum predicted heart rate and cooling down phase for 5 minutes and immediately after 2 hours postprandial condition the blood sample was collected from antecubital vein immediately before and after exercise session.

The typical exercise sessions consisted of:

- **Warming up Phase:**

Each patient started warming up for 10 minutes on arm or leg ergometer without resistance as a preparation for the exercised muscles and enhance the blood supply for the exercising muscle to avoid fatigue or injury.

- **Active Phase:**

The active phase in form of arm or leg ergometer exercise was conducted in 20 minutes and within 50% to 75% of predicted maximum heart rate (in which the predicted maximum heart rate = $220 - \text{age}$)²². Exercise with a constant resistance kept equal to 50watt and constant cycling frequency is kept at 50 repetitions per minute for arm ergometry and for leg ergometry the resistance kept equal to 50 watt and constant cycling frequency is kept at 50 repetitions per minute

- **Cooling Down Phase:**

The cooling down was conducted for 5 minutes on arm or leg ergometer without resistance. Every patient performed cooling down for 5 minutes after active phase to prevent fatigue or injury. Patients went to the lab again to take his/her second blood glucose sample after finishing the exercise. The duration of the session totally was 35 minutes. And the program duration was three times per week for three months.

Statistical analysis

Data collection and statistical analysis:

- 1- All patients participated in this study were with type II DM and they performed upper extremity ergometry exercises and lower extremity ergometry exercises. Blood glucose level were measured prior to and following each session three times each week for 12 weeks.
- 2- Data that collected from both groups before and after the treatment program concerning, blood glucose was statistically analyzed utilizing:
 - **Unpaired T test:**
It was utilized to compare among mean values of age, weight as well as height for both groups. Pre-treatment mean values of blood glucose among both groups. Post treatment mean values of blood glucose among both groups.
 - **Paired T test:**
It was utilized to compare among pre and post treatment mean values of blood glucose within each group.

Results

The aim of the study was to compare the impact of lower- and upper-extremity exercise on glucose levels in old women. Forty women who were hyperglycemic took part in the study. Patients were randomized into 2 groups, with each group consisting of 20 female patients. Group A engaged in an upper-extremity training program three times weekly for three months, while Group B engaged in a lower-extremity exercise program on the same schedule. Blood glucose levels were measured before and after the intervention and compared statistically between the two groups.

Descriptive Data of Both Groups (A and B):

The mean (\pm SD) of age of group A was 64.05 ± 3 years, while mean (\pm SD) of weight was 82.55 ± 6.34 kg, as well as the mean (\pm SD) of height was 175.55 ± 6.36 cm. In group B, the mean (\pm SD) of age was 63.75 ± 2.78 years, while mean (\pm SD) of weight was 83.15 ± 6.05 kg, as well as the mean (\pm SD) of height 176.9 ± 6.18 cm. No significance differences have been detected among both groups concerning mean of age, weight as well as height ($p > 0.05$) as revealed in (Table 1).

Table (1): Demographic data of both groups

Item	Group A			Group B			t-value	p-value	Sig.
	$\bar{X} \pm SD$	Range		$\bar{X} \pm SD$	Range				
		Min	Max		Min	Max			
Age (years)	64.05 ± 3	60	70	63.75 ± 2.78	60	69	0.32	0.74	NS
Weight (kg)	82.55 ± 6.34	71	92	83.15 ± 6.05	73	92	-0.30	0.76	NS
Height (cm)	175.55 ± 6.36	165	182	182.9 ± 6.18	186	179	-0.68	0.50	NS

*Kg: kilogram, cm: centimeter, \bar{x} : mean, SD: standard deviation, P: probability, S: significance, NS: non-significant, NO: number.

A. Evaluation of Blood glucose level:

I: Comparison of mean values of blood glucose level: pre and post treatment in group A:

After treatment, blood glucose levels in group A decreased from a pre-treatment mean of 279.9 ± 60.99 mg/dl to a post-treatment mean of 221 ± 36.50 mg/dl. The mean difference was 58.95 while the mean improvement was 21.04 %. As can be seen in (Table 2), there was a highly significant difference in blood glucose levels before and after treatment.

Table (2): Comparison between pre and post treatment mean values of blood glucose level for group A

Item	Blood glucose level	MD	% of improvement ↓	t-value	p-value	Sig
	$\bar{X} \pm SD$					
Pre	279.9 ± 60.99	58.95	21.04	6.90	0.0001	S
Post	221 ± 36.50					

* \bar{x} : mean, SD: standard deviation, MD: mean difference S: significant.

II: Comparison between pre and post treatment mean values of blood glucose level for group B:

Pre-treatment, blood glucose levels in group B mean was 281.7 ± 38.69 mg/dl, while post treatment, they decreased to 247.15 ± 37.82 mg/dl (mean SD). The mean difference was 34.55 while the percent of improvement (\downarrow) was 12.26%. Blood glucose levels were significantly different before and after treatment ($p = 0.0001$), as indicated in (Table 3).

Table (3): Comparison between pre and post treatment mean values of blood glucose level for group B

Item	Blood glucose level	MD	% of improvement ↓	t- value	p-value	Sig.
	$\bar{X} \pm SD$					
Pre	281.7 ± 38.69	34.55	12.26	10.11	0.0001	S
Post	247.15 ± 37.82					

* \bar{X} : mean, SD: standard deviation, MD: mean difference S: significant.

III. Comparison between pretreatment mean values of blood glucose level of both groups (A and B):

Blood glucose levels in Group A mean was 279.9 ± 60.99 mg/dl while in Group B, the mean was 281.7 ± 38.69 mg/dl. As revealed in (Table 4), there was no statistically significant difference in baseline blood glucose levels between the two groups (p= 0.91).

Table (4): Comparison between pretreatment mean values of blood glucose level of group A and B

Item	Blood glucose level	MD	t- value	p-value	Sig
	$\bar{X} \pm SD$				
Group A	279.9 ± 60.99	1.8	-0.10	0.91	NS
Group B	281.7 ± 38.69				

* \bar{X} : mean, SD: standard deviation, MD: mean difference, NS: non-significant.

IV. Comparison between Post treatments mean values of blood glucose level of both groups (A and B):

Post treatment, the mean blood glucose levels in Group A was 221 ± 36.50 mg/dl, while the mean blood glucose levels in Group B was 247.15 ± 37.82 mg/dl (mean SD). According to the data in (Table 5), after treatment, group A had significantly lower mean blood glucose levels than group B (p = 0.03).

Table (5): Comparison between post treatment mean values of blood glucose level of group A and B

Item	Blood glucose level	MD	% of improvement ↓	t- value	p-value	Sig
	$\bar{X} \pm SD$					
Group A	221 ± 36.50	26.15	11.83	-2.22	0.03	S
Group B	247.15 ± 37.82					

* \bar{X} : mean, SD: standard deviation, MD: mean difference S: significant.

V: Comparison between percentages of improvement ↓ in blood glucose level in both groups:

Blood glucose levels improved by 21.04% in group (A) compared to 12.26% in group (B), while blood cholesterol levels improved by 11.19% in group (A) compared to 6.06% in group (B), as indicated in (Table 6).

Table (6): Percentage of improvement in blood glucose (A) and (B):

Percent of Improve (↓)	Group(A)	Group(B)	t.value	p.value
Blood glucose level ↓	21.04	12.26	-2.22	0.03

Discussion

Analysis of the findings of the study showed that both upper limbs and lower limbs exercises have a positive impact on regulating (decreasing) blood glucose level in elderly diabetic females and results showed that the improvement (decrease) in blood glucose level by upper limbs exercise was more significant than the improvement (decline) achieved through lower limbs exercise, that may be due to insulin resistance and production of lipase enzyme are more in upper limbs more than in lower limbs and insulin sensitivity in upper limbs was more than in lower limbs due to the difference in vascular response between upper limbs and lower limbs (Newcomer et al., 2004)²³.

The reduction in blood glucose level following the training may be due to increased skeletal muscles mass which led to improvement in total insulin-mediated glucose uptake as skeletal muscles tissues are the main location of insulin-mediated glucose (Adam et al., 2005). & (Turcotte and Fisher, 2008)^{24,25}.

The results of Deffranzo, (2009)²⁶ agree with the findings of the present study as the glucose clearance is higher in arm than leg muscles which may indicate more beneficial impact of upper limbs than lower limbs exercise in old patients with DM.

Patients with type II DM may benefit from arm exercises for glycemic control, according to study results by Bergfors et al., (2005)²⁷ due to better preserved insulin sensitivity in the upper limbs muscle than lower limbs muscles- also, Arne et al., (2006)²⁸ performed a study to evaluate the effects of acute arm cycling exercises for 45 minutes on glycemic response. They found that there is marked decrease in metabolic response especially in blood glucose level following an exercise session.

Lazarevic et al., (2006)²⁹ demonstrated that regular cycling exercises has beneficial effects on glycemic control, insulin resistance, cardio vascular risk and oxidative stress-defense parameters. As regular cycling exercises increased the insulin receptors sensitivity. Exercise is often recommended as one of the primary management methods for individuals with a new diagnosis of type II diabetes, which is consistent with the findings presented in Kirwan., (2017)³⁰. All programs

aimed at preventing diabetes and obesity include behavioral and dietary changes as well as physical activity. Regular physical activity, whether aerobic, resistance, or a combination of the two, helps the body better regulate glucose.

On the other hand, the results of Yuzo et al., (2003)³¹ contradicted the findings of the present study as they demonstrated that serum glucose decreased more significantly after lower limbs than upper limbs ergometry exercises but the difference in the findings from the present study may be due to different program duration as their program was conducted only for two months.

Also, Kiens, (2006)³² disagree with the findings of the present study in their study that showed reduction of muscles insulin resistance in type II diabetes after ergometry exercises. But the blood glucose level was decreased after lower limbs exercises greater than upper limbs exercises. The differences in the findings of this study from the present study can be attributed to the difference in number of patients as this study was conducted on 25 patients only.

Since this study only involved 25 individuals, the results may not generalize to a larger population due to methodological limitations associated with the small sample size. Blood glucose levels in older individuals with type II diabetes can be successfully managed with a combination of upper- and lower-extremity ergometry exercises, as was recently concluded, but the effect on decreasing blood glucose level is higher in upper limbs group than in lower limbs group. This may be attributed to more increase in total insulin-mediated glucose uptake, an increased number of insulin receptors in the muscle cell in upper limb more than lower limb.

Conclusion

A program of upper limbs ergometry exercise for 3 months, 3 sessions per week reduced the elevated blood glucose level in elderly type II diabetes. So, the elderly women with type II diabetes should be advised to perform moderate arm exercises.

Acknowledgment

Special thanks go to the participants who vitally took part in the current study. All thanks and appreciation go to our families for their continuous support and endless patience. Also, our deep gratitude and thanks go to everyone who stood there for help along the journey.

Author Contributions

HAA devised the experiment, carried it out, and produced the paper. Throughout the experiment, data analysis, and manuscript review, **MYG, NMA and THM** provided ongoing guidance and ideas. The final version was read and approved by all authors.

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