EFFECT OF A SINGLE BOUT OF HAND MUSCLE EXERCISE ON BLOOD GLUCOSE LEVELS IN DIABETICS

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ABSTRACT

Background: Type 2 Diabetes mellitus has become an epidemic world-wide. Lack of physical activity and high calorie diet increase the prevalence of Type 2 diabetes. Type 2 diabetes and its complications can be prevented by regular exercises.

Many studies have assessed the effect of exercises on blood glucose levels where larger group of muscles are involved. There are no exercise studies involving smaller groups of muscles like forearm and digital muscles.

Aim: To evaluate the effect of a single bout of hand muscle exercise on the blood glucose level in diabetics.

Materials and Methods: Subjects were Type 2 diabetics, between the age group of 45 – 65 years. Exercise was done with a digitalized hand-grip dynamometer.

Results: Capillary blood glucose levels before and after exercise was estimated and analyzed with Students paired t test. Significant decrease in the blood glucose levels after the exercise was noted. ($p<0.0001$).

Conclusion: Exercises involving smaller muscles like the hand muscles can also reduce the blood glucose levels. So these types of exercise can be recommended to diabetics who cannot do the regular aerobic or resistance exercises.

Key words: Type 2 diabetes mellitus, hand muscle exercise, GLUT 4.

INTRODUCTION

Type 2 Diabetes mellitus has become an epidemic world-wide. According to International Diabetes Foundation the disease affects 246 million people world-wide and is expected to affect about 380 million by 2025. It is alarming to know that the prevalence of this disease has increased among children and adolescents [1]

Sedentary life style and intake of high-calorie food results in obesity [2]. Accumulations of fat in the viscera or deep subcutaneous adipose store in obesity results in insulin resistance, cardiovascular diseases and metabolic syndrome. Insulin resistance in Type 2 diabetes mellitus leads to micro and macro vascular complications affecting the kidneys, retina, cardiovascular system and the nerves [1].

Diabetes and its complications deteriorate the quality of life and can cause early death. Pharmacological and non-pharmacological (dietary modifications & exercise training) interventions are important to prevent Type 2 diabetes mellitus and its complications and to improve the quality of life of the patients with Type 2 diabetes mellitus. Dietary changes like reducing the consumption of high fatty, carbohydrate rich food and increasing the intake of food rich in dietary fibers are suggested [3]. American Diabetes Association recommends regular exercise/Physical activity for longer than 30 minutes every day for prevention of diabetes in high risk group (Prediabetics) and in diabetics for control of blood glucose levels, maintenance of body weight and reduction in risk of cardiovascular disease [2]. In a study done by Janko et al on Prediabetics with lifestyle modification, the incidence of diabetes was reduced by 58% [4].

Many studies have been conducted to show the effectiveness of different types of exercises like aerobic exercise or Resistance training exercises or combined training on insulin sensitivity, cardiovascular function [5], endothelial function [6], reduction in body weight, increase in muscle mass and strength, decrease in blood

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glucose levels [5] etc. Each type of exercise has shown to have its own individual benefits and both types decrease blood glucose levels. Studies have also been conducted to assess the effect of a single bout of exercise [7] /short term exercise (for 1week - 4weeks etc) [8] /chronic exercises (for1-2 years) on blood glucose levels and insulin sensitivity. Even a single bout of exercise has shown to increase insulin sensitivity and decrease blood glucose levels and the effects last for 24 – 72 hours post-exercise [9].

All the studies mentioned above have involved large group of muscles of the upper limbs/ lower limbs/whole trunk as in walking, running, jogging, cycling etc (aerobic training) and strength training exercises of large muscles. No study has been conducted to assess the effect of exercise using the smaller group of muscles like the forearm and digital muscles on blood glucose levels. These types of exercises can be of use to patients who may not be able to do the regular type of exercise mentioned above due to reasons like old age, arthritis, obesity, cardiovascular illness, foot ulcers etc. So if hand muscle exercises can reduce blood glucose levels they can be suggested for patients with above problems.

MATERIALS AND METHODS

50 subjects with Type 2 diabetes mellitus were selected for the study from a Private diabetes specialty hospital. Both male and female subjects between the age group of 45 – 65 years were included in the study. Ethical clearance was obtained from the institutional ethical committee. Written informed consent was obtained from the subjects.

Patients with Type 2 Diabetes mellitus, of both sexes between the age group of 45 – 65 years of age and without any other complications other than hypertension (under control) and only on oral anti-diabetic drugs were included in the study. Subjects with high blood pressure and very high blood glucose levels (>500mg/dl), on treatment with insulin, with cardiovascular and other complications or pain and inflammation in upper limbs were excluded from the study.

Subjects were screened with general physical examination which included Height in cm, weight in Kilograms, Blood pressure and pulse rate. BMI was calculated for all the subjects.

ABOUT THE INSTRUMENTS USED

1. Digital hand-grip dynamometer:

This instrument was designed and constructed in house in the department of Bio-Medical engineering. The hand-grip dynamometer (Fig 1) has a load cell and a digital display module to display the load in Kilograms against which the muscles are contracting. The load cell converts force generated by muscle contraction into analog voltage; this analog voltage in turn is converted to digital form and displayed in kilograms. Calibration was done using standard weights of 5Kilograms and 10Kilograms.

2. Automated glucometer- **(AccusureTM, ver 1.0, 2009-01),** using amperometric technique is used to check the Capillary blood glucose levels (CBG) levels.

3. **Sphygmomanometer** was used to record the blood pressure.

Study protocol: The study was conducted in all the subjects, during the morning hours. The subjects were asked to have breakfast and 1 - 2 hours after the meal the study was conducted.

The subjects were explained about the procedure and written informed consent was obtained from them. Baseline CBG level was estimated. Metronome software was used to standardize the number of contractions per minute for all the subjects. The subject was comfortably seated and he/she was initially asked to compress the hand-grip maximally and the Maximum voluntary contraction (MVC) load in kilogram was noted. Then the subject was asked to follow the ticking of metronome and to press the hand-grip to 30% of their maximum voluntary contraction and to relax alternately, and this cycle of one contraction and relaxation were repeated. 30 contractions per minute were done. This was done for 15 minutes with one minute rest period between every 3 minutes to prevent fatigue. At the end of the protocol immediate Pulse rate & blood pressure were recorded. After exercise CBG was estimated after 5 minutes.

STATISTICAL ANALYSIS

Statistical analysis was done using the SPSS software. Mean values of the Capillary blood glucose (CBG) for fifty subjects before and after exercise were compared and analyzed using Student paired T test. P value <0.05 is considered to be significant.

RESULTS

This study included 50 subjects with Type 2 diabetes mellitus and their CBG levels were compared before and after exercise.

Mean values of CBG before exercise and after exercise were compared for all the subjects as a whole and also for males and females separately. The subjects (males and females) were categorized based on their age group and their CBG levels were analyzed individually for the age groups.

Table 1 shows that there is a definite decrease in the mean blood glucose levels following exercise of all the subjects and is statistically significant (p<0.0001). This shows that this type of exercise can significantly decrease the CBG levels.

Table 2 shows the mean values of CBG levels in the females before and after exercise where there is a significant drop (p<0.0001) by 24 to 36 mg/dl.

Table 3 shows the mean CBG levels in the males in various age groups and they also have a significant drop in CBG (p<0.0001) levels by 18 – 44 mg/dl.

P value for correlation between the BMI and the drop in blood glucose levels after exercise were > 0.05 and it was not considered significant.

Table 1: Mean and standard deviation of significant variables about the study subjects. (BE – Before exercise, AE – After exercise)

Variables	Mean of variables
Mean Capillary Blood Glucose (BE)	213.42 ± 76.52 mg/dl
Mean Capillary Blood Glucose (AE)	181.92± 76.40mg/dl
Mean age of the subjects	53.94 years
Mean BMI of the subjects	28.04
Mean years of diabetes	5.19 years

Table 2: CBG levels in females before and after exercise given as Mean and standard deviation

Age in years	No: of subjects	Mean of CBG (BE)in mg/dl	Mean of CBG (AE) in mg/dl	P value
45 - 50	10	163.8 ± 74.51	127.7 ± 79.98	< 0.0001
51 - 55	10	238.9 ± 110.84	207.6 ± 108.63	
56 - 60	1	297	270	
>60	3	396.3 ± 1.52	372 ±23.15	

Table 3: CBG levels in males before and after exercise given as Mean and standard deviation

Age in years	No: of subjects	Mean of CBG in mg/dl (BE)	Mean of CBG in mg/dl (AE)	P value
45 - 50	7	125.42 ± 69.81	107.71 ± 48.29	< 0.0001
51 - 55	5	178.8 ± 34.22	151.4 ± 14.32	
56 - 60	11	226.27 ± 73.55	203.28 ± 61.63	
>60	3	299 ± 25.92	255 ±29.93	

DISCUSSION

Exercise decreases blood glucose levels. Any form of exercise where there is muscle contraction, glucose uptake in the muscle is favored [5]. It is clearly evident in our study that a single bout of such hand muscle exercise involving the smaller group of muscle has decreased blood glucose levels. Highly significant drop in blood glucose levels by such exercise is astounding and needs explanation.

Exercise decreases blood glucose levels by 3 mechanisms – i) Increased delivery of glucose to tissues by increasing perfusion, ii) Increasing glucose uptake by inserting more number of GLUT 4s (Glucose transporters) on muscle membrane and iii) By phosphorylation of glucose inside the muscle. During exercise, slow oxidative type of skeletal muscles rely more on the first and third mechanisms for their glucose uptake and fast twitch glycolytic fibers depend more on insertion of more number of GLUT 4s for their uptake [9]. Moreover the GLUT 4s in fast twitch fibers are considered to be more

responsive to contractions than GLUT 4s in slow twitch fibers which are highly responsive to insulin. Type 2 diabetes mellitus considered being more of a muscle disease where insulin action is resistant. Michael et all have shown that in Type 2 diabetes mellitus the amount of slow twitch fibers in a muscle were considerably decreased and fast twitch fibers were not much affected. The decrease in slow twitch fibers and also a decrease in their GLUT 4 content have made us to think that Type 2 diabetes mellitus is more of a slow twitch fiber disease [10].

The hand muscle exercises done in our study includes only the muscles of the forearm, fingers and palm. These peripheral small groups of hand muscles are composed of more number of fast twitch fibers than slow twitch fibers [11]. The type of exercise used in our study has involved more of fast twitch fibers which are more responsive to contractions and are relatively not affected in diabetics, have decreased the blood glucose levels significantly even with a very small bout of exercise [10].

Jorge et al in their meta-analysis study compared the effectiveness of structured exercises (Both aerobic and resistance training and combined effects) with physical activity alone (unstructured activities involving muscle contractions) and have shown that structured exercises were more effective in decreasing HbA1c than physical activity alone, but when physical activity combined with dietary regulation physical activity was also able decrease HbA1c[12]. In our study we have not suggested any regulation in the diet and yet there was a marked decrease in blood glucose levels following such exercises.

We had selected the time duration of 1 - 2 hours post-prandial (after breakfast) for conducting the study, to find out if these hand muscle exercises were able to decrease the glucose levels during their rising phase. It is clear from our study there is a significant drop even during this period.

This study had to be extended for the regular use of diabetic patients and therefore we tried using other easily available hand strengthening instruments which can produce similar type of contractions. Some subjects were given the hand-grippers and asked to do similar grip exercise with that instrument for 15 minutes. In few patients stress balls were also given and they were made to squeeze the ball, to their maximum effort involving all the fingers and forearm muscles, and to contract and relax alternatively for 15 minutes. In most of the subjects there was a decrease in blood glucose level by 20 – 30mg/dl after the exercise. (Data not shown).

CONCLUSION

To summarize, all types of skeletal muscle contractions either aerobic exercises or resistance training exercises or leisure time physical activity [13] (involves regular household activity, gardening, and mild forms of exercises) can reduce blood glucose levels to different levels. Our study has proven this fact and we have shown that exercise of smaller muscles also decrease the blood glucose levels. We have attributed the highly significant decrease in blood glucose levels following the exercise to the presence of more of fast twitch glycolytic fibers in the smaller finger muscles and their intactness in Type 2 diabetes mellitus and their GLUT 4s sensitivity to muscle contractions.

Limitations and further extension of the study: Small muscle exercises of very short duration are able to decrease blood glucose levels. This study was done at a single shot and therefore only the blood glucose levels were analyzed before and after exercise. It would be more beneficial if we extend this study for 3 months where the subjects do regular hand grip exercises and their HbA1c levels are also assessed before and after exercise.

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