INFLUENCE OF AEROBIC TREADMILL EXERCISE ON BLOOD GLUCOSE HOMEOSTASIS IN NONINSULIN DEPENDENT DIABETES MELLITUS PATIENTS

Shivananda Nayak*, Arun Maiya** and Manjunath Hande***

* Department of Biochemistry, Kasturba Medical College, Manipal

** Department of physiotherapy, College of Allied Health Sciences, Manipal

*** Department of Medicine, Kasturba Medical College, Manipal

ABSTRACT

The role of treadmill exercise on blood glucose homeostasis in noninsulin dependent diabetes mellitus (NIDDM) were studied using males between age of 45 and 60 years (X-52), who were clinically and biochemically-confirmed cases of NIDDM were taken into study group. Control group comprised of 10 males between age group of 45 to 60 (X-53) years. All the subjects were assessed by physician and were investigated to confirm diabetic status. The whole study period was extended for 6 weeks. The significant decrease in postprandial blood sugar (44.4mg% for the study group and 32.2mg% for the control group) with a significant inter group difference ($P < 0.05$) was observed. The mean decrease in fasting blood sugar (39.4mg% for the study group and 27.4mg% for the control group), with a marginal inter group difference ($P < 0.05$) was observed. The treadmill exercise was found to be a definite tool in addition to drug and diet in glycemic control.

KEY WORDS

Fasting blood sugar, postprandial blood sugar, Noninsulin Dependent Diabetes Mellitus and Treadmill exercise

INTRODUCTION

Diabetes mellitus is a metabolic disorder that has an actual or relative insufficiency of insulin, which results in inability to utilize glucose and hence elevated blood glucose levels, called hyperglycemia (1). It is common in Indians and it affects about 2% of population (2,3). The diagnosis is confirmed by following blood parameters fasting blood sugar (FBS), post prandial blood sugar (PPBS), oral glucose tolerance test (OGTT) and urine examination for reducing sugars.

Treatment modalities of hyperglycemia consist of a triad of drugs, diet and exercise. Each has a specific role in promoting glucose uptake and hence balancing blood glucose levels (4). Regular exercise is a valuable supplement to diet (5). The brisk walking is the best form of exercise to any NIDDM patients. The natural walking involves large group of muscles of lower limb along with rhythmic upper body muscular work.

* Author for Correspondence

Dr. Shivananda Nayak. B
Associate professor
Department of Biochemistry
Kasturba Medical College
Manipal 576104, India
E-mail: snayak25@yahoo.co.in

Treadmill aerobic walking stimulates all the natural walking features and has added advantage. The treadmill is a motor driven or manual exercising equipment. The study involves the efficacy of exercise as supplement to diet and drug in controlling diabetes.

MATERIALS AND METHODS

Treadmill (ESPEC DYNAMED), LIFESCOPE 9 Oscilloscope monitor for vital parameter (Heart rate, respiratory rate and blood pressure) monitoring, Sphygmomanometer, Non Stretchable measuring inch tape and weighing scale

Patients

In this study all the 20 patients were initially screened by physician clinically and biochemically to confirm the diabetic status. The subjects with known cardiac, pulmonary, diabetic neuropathy and musculoskeletal problems were excluded from the study and control group.

The study group consists 10 males between age group 45 and 60 years (X-52), who were clinically and biochemically-confirmed cases of NIDDM. Only the NIDDM subjects who were willing to participate in the experimental study were included into this group. The NIDDM subjects who were having renal and other diseases were excluded from the study.

The control group consisted of 10 males between age group of 45 to 60 (X-53) years who were clinically and biochemically confirmed cases of NIDDM. The subjects who were not willing to participate in the exercise programme were included in the control group. All the subjects were assessed by physician and were investigated to confirm diabetic status.

Treatment protocol

The whole study period was extended for 6 weeks. At the beginning of the study, the blood glucose levels were investigated for PPBS and FBS for both the groups. Subjects from both groups were examined in detail for recording weight, height, body mass index (BMI), and waist-hip ratio. The Muscular stretchability and strength in lower limbs were assessed and in case of tightness or weakness appropriate physical therapy program was instituted for the study group.

The motor driven treadmill (ESPEC DYNAMED) was used for the study. It provides computerized programming parameters for distance traveled (Kilometers), calories used (Kilocalories) and speed (RPM). The calibration of treadmill is done before starting treatment. The familiarization of treadmill was given to the patient before the study.

Each experimental session lasted for one hour including five minutes of warm-up, 50 minutes of aerobic treadmill walk and 5 minutes of cool-down. They are instructed to report in case of any symptoms, which are indicative for termination of the exercise. The vital parameters for Heart rate (HR), respiratory rate (RR) and blood pressure (BP) are recorded in supine position. The active warm-up exercise comprised of rhythmic stretching and active movements of limbs and breathing exercises for 5 minute. Then monitoring of BP, HR and RR electrocardiogram was established. The patient is subjected to walk on treadmill for 50 minutes. The intensity of exercise is regulated by maintaining constant speed of 3.4 Km/hr, fixed inclination of 4.2 angle and Borg's score of 13-14 for rate of perceived exertion.

The subject is closely observed for any parameter change or any symptoms. After the termination of exercise the vital parameters were recorded immediately and during recovery at the 3rd minute, with the passive recovery. All 10 patients completed five sessions per week of program for 6 weeks, uneventfully. The blood investigations were repeated for both the groups at the end of six week. The study group subjects were advised to continue brisk walking after the supervised graded treadmill exercise as home programme. These patients were periodically reassessed once in two months to know the diabetic status. All the subjects of study group were continued their home programme so that the blood glucose was

maintained under control. However the control group subjects did not show any decrease in the blood glucose level during the periodic assessment.

Parameters studied

Fasting and Postprandial blood sugar estimation-The blood sugar was estimated using glucose oxidase – peroxidase method

Statistical Analysis of results:

Results, expressed as mean $\pm$ SD were evaluated by student's 't' test. Values of $p < 0.05$ were considered statistically significant.

RESULTS

Out of ten subjects in the study group, six were overweight, with body mass index more than 25 and four were of normal weight with body mass index of 22 to 25. There was not much variation in the blood glucose level of the six overweight subjects of study group. The obesity and sedentary lifestyle were one of the most common risk factor for diabetes mellitus in Indian population. Therefore body mass index of more than 25 is a risk factor for diabetic's. All completed the planned one and a half months of treadmill endurance exercise program without any complications.

The pre-exercise blood sugar levels of study group ranged from 160-198 for FBS and 190-220 for PPBS, the post exercise levels were 130-168 for FBS and 150-176 for PPBS.

For control group the beginning blood glucose values were 150-201 for FBS and 194-221 for PPBS. After 6 weeks of observation the values were 150-180 for FBS and 164-198 for PPBS.

The blood glucose levels were analyzed to know the inter-groups fall in the FBS and PPBS (Figure 1 and 2). The mean fall in FBS was 39.4 mg % for the study group and 27.4mg% for the control group and the inter-group fall in FBS was significant (p value < 0.05). The fall in PPBS was 44.4mg% for the study group and 32.2 mg% for the controls; the inter-group fall in PPBS

Table 1. Inter-Group comparison of change in Blood glucose Parameters in study Vs control.

Parameter	Control	Study
FBS1 – FBS2	27.4 $\pm$ 9.720	39 $\pm$ 8.315*
PPBS1- PPBS2	32.2 $\pm$ 6.972	44.6 $\pm$ 8.617*
FBS1= Fasting blood sugar before exercise FBS2= Fasting blood sugar after exercise, PPBS1= Postprandial blood sugar before exercise PPBS2= Postprandial blood sugar after exercise Values are mean $\pm$ SD; n =10 * $p < 0.05$ vs. control student 't'-test

Figure 1 Comparison of change in fasting blood sugar in study Vs control (initial and after 6 weeks)

Figure 2 Comparison of change in postprandial blood sugar in study Vs control (initial and after 6 weeks)

was significant (p value <0.05) (Table 1). The study group subjects lost 1 to 3 kg of weight. The patient reported a subjective feeling of well being.

DISCUSSION

The deficiency of the insulin, the failure of glucose uptake leads to backup of glucose in the blood, resulting in hyperglycemia. The treatment of diabetes consists of, education, exercise, diet, oral hypoglycemic drugs and subcutaneous insulin therapy (6).

The triad of insulin, diet and exercise has been the basis for treatment of diabetes for the past 60 years (7). Each individually or in combination has place in the treatment regimen. The exercise program in conjunction with diet and oral medication can cause glycemic control, weight reduction, reduction in the cardiovascular risk factors and improvement in the mental well being of the patient (8,9). We studied efficacy of the treadmill walking exercise as a supplement to diet and drug in controlling the diabetic mellitus.

Naturally, the patients don't like dietary restriction or exercise because the diet is self-denial and exercise means an effort on his part. The oral drug intake is the best treatment from the patients' point of view, but it has certain disadvantages and side effects. The regular endurance treadmill walking exercise can decrease BP, increase oxygen consumption and transport and increase collateral circulation. The exercise can facilitate the glycemia control by increased insulin sensitivity, improved fuel for oxidation, and increased storage of muscle glycogen (10).

As the endurance type exercise start in the beginning, the muscle glycogen available for short period. As the muscle activity is prolonged glycogenolysis is the source of increased availability of glucose. After 15 minute of exercise hepatic gluconeogenesis begins. When exercise is prolonged over 30 minute, the free fatty acid generated by adipocyte lipolysis. In diabetic the conversion from resting to working metabolism occurs more rapidly due to higher basal circulating levels of free fatty acid and circulating gluconeogenic substrates (11).

Wahren and colleagues reported that exercise in poorly controlled diabetes, leads to increased blood glucose and ketoacids. The insulin is the predominant hormone influencing the regulation of metabolic fuel available in man. The working muscle is more sensitive to insulin action than the muscle at rest, resulting in greater assimilation of glucose per unit of insulin during the exercise. The increased sensitivity of muscle to insulin occurs with mild to moderate exercise. The exercise increases the blood flow to working muscle so that it increases in size of perfused capillary bed and available number of insulin receptors, counterbalancing this increased sensitivity to insulin, ultimately leading to concomitant decrease in the production of pancreatic insulin in NIDDM during exercise (12).

Costrill and co-workers reported that after six weeks of treadmill walking, insulin binding to monocyte receptor sites increased and allowed greater insulin mediated glucose uptake within promoted oxidation of glucose and its glycolytic products. There is increased glycogen utilization and storage during and after physical activity influencing glucose metabolism, so that there is enhanced glucose uptake associated with endurance exercise (13).

The endurance exercise is prescribed for diabetic patient in the same manner as diet and insulin. The amount of exercise that a patient is expected to perform can be quantified. The four parameters considered during the exercise prescription are mode of exercise, duration of exercise, frequency of exercise and intensity of exercise

A long duration and low intensity endurance exercise

can yield better result than high intensity short duration program. The exercise session of beyond 30 minutes has additional cardiovascular benefit. The initial exercise program should include moderate duration of 30 minutes. If the patient doesn't have musculoskeletal injury or adverse symptoms, the duration may be gradually increased by 5 minutes every week. The optimal frequency is 5 days per week. The intensity of the exercise prescribed should be demanding to meet both the glycemic control and cardiovascular conditioning. The target can be set by, $\text{Target HR} = 0.6 (\text{HR}_{\text{max}} - \text{HR}_{\text{rest}}) + \text{HR}_{\text{rest}}$. Borg's scale for RPE between 13-14 (some what hard) which corresponds to a heart rate of around 70-80% of maximum, which would give an intensity of exercise within the aerobic target zone – described by American College of Sports Medicine (ACSM 1990). In our study we found that the aerobic exercise is a definite tool to control blood glucose level. The mechanism by which exercise facilitate glucose uptake is due to the fact that working muscle is more sensitive to insulin than the muscle is at rest. With the endurance exercise the sensitivity of the muscle to the insulin increases. The number of insulin receptors in the working muscle is more as compared to the muscle at rest, which leads to decrease in the production of pancreatic insulin and thereby muscle can utilize more glucose even with decreased insulin production, which results in decreased glucose level. During exercise subjects rate their individual perceptions of physical exertion on a numerical scale. This method also allows individuals to self-select the intensity of their exercise according to how they feel of any particular occasion and this is important in planning the home program aerobic exercise (14).

REFERENCES

1. Benne, J.A and Plaum, F. Cecil (1990). Text Book of Medicine 20th edn. Vol. II. W.B. Saunders Company; London, p1258-1277.
2. Manson, J.E. and Rimm, E.B. (1991). Physical Activity and incidence of NIDDM In women. *Lancet* 338, 774-778.
3. McArdle. (1991). Exercise Physiology, 3rd ed. Philadelphia. Lea and Febiger. p599-608.
4. Richter, E.A. and Ruderman, N.R. (1981). Diabetes and exercise. *American Journal of Medicine*. 70. 201-209
5. National Institute of Health (1987). Consensus development conference on diet and exercise in NIDDM. *Diabetes care*. 10. 639-644
6. Krall, L.P. and Beaser, R. S. (1989). *Joslin Diabetes Manual*. 12th edn. Lea and Febiger, Philadelphia. 1-19. 81-91.

7. Erikson, K.F. and Lindgarde, F. (1991). Prevention of NIDDM by diet and exercise. *Diabetologia*. 34. 891-898.
8. Franz, M.J (1997). Lifestyle modification for Diabetes management *Endocrinology and Metabolism clinics of North America*. 26. 499-509.
9. Giacca, A. and Elane, Y. (1998). Glucose production utilization and cycling in response to moderate exercise in obese subjects with NIDDM. *Diabetes*. 47. 1763-1770.
10. Vranic, M, and Berger, M. (1979). Exercise and diabetes mellitus. *Diabetes*. 28. 147-162.
11. Schneider, S.H. (1990) Exercise and NIDDM. *Diabetes care*. 13. 785-789.
12. Wahren, J. and Felig, P. (1971). Glucose metabolism during leg exercises. *J clinical investigation*. 50. 2715-2725.
13. Hermansen, L, and Saltin, B. (1969). Oxygen uptake during maximal Treadmill and Bicycle exercise. *J. Applied Physiology*. 26. 31-37.
14. Paley, C.A. (1997). A way forward for determining optimal aerobic intensity. *Physiotherapy*. 83. 620-624.