Effectiveness of structured exercise program on insulin resistance in type 2 diabetes mellitus with peripheral neuropathy – A preliminary report

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Abstract

Introduction: Type 2 Diabetes Mellitus (T2DM) is characterized by elevated glucose levels in circulating blood, caused by impairment in glucose tolerance development of insulin resistance & relative insulin deficiency.In the Indian population, insulin resistance is one of the strong reasons for altered glycemic control, even though exercise training is found to be useful in glycemic control along with the standard medical care.

Aim: To find out the effectiveness of structured exercise program on insulin resistance by using Fasting insulin level and Homa-IR in T2DM with peripheral neuropathy.

Material and Methods: In the study conducted, a total of 10 T2DM with peripheral neuropathy in the age group of 30 - 65 years were included. The criteria of exclusion for the participants were those with T1DM, respiratory disease, neurological disorders, and musculoskeletal problems.

Results: The average age of the participants was 58.80 ± 9.27. All the participants had a history of T2DM with a mean duration of 10.70 ± 6.29 years. All participants were screened clinically and biochemically and given a set of structured exercise program three times a week for 12 weeks along with standard medical care.

Conclusion: The 12 weeks of structured exercise program training was effective on insulin resistance and glycaemic control in T2DM with peripheral neuropathy.

Keywords: Insulin resistance, Aerobic exercise; Resistance training, Glycosylated HB, Homa-IR, Metabolic syndrome.

Introduction

T2DM is considered one of the fastest growing non communicable diseases worldwide which is characterized by, hyperglycemia resulting from defective insulin secretion, insulin action or both. Diabetes complications are the leading causes of morbidity and mortality which can be prevented by taking prescribed medication accurately along with maintaining a healthy diet and physical activity.With this, the long-term complications can be delayed.[1] There has been an increase in the cases of T2DM across the globe. According to the International Diabetes Federation Atlas (7th edition), 415 million adults worldwide have diabetes mellitus and it is projected to increase to 642 million by the year 2040.[2] In T2DM there will be elevated glucose levels in circulating blood, caused by impairment in glucose tolerance which leads to the development of Insulin Resistance (IR). It is known that a disproportionate accumulation of subcutaneous and abdominal fat contributes to the desensitization of insulin receptors that is characterized by an inhibited uptake of glucose within skeletal muscle, and an impaired ability to suppress endogenous glucose production. IR in diabetic individuals is associated with abnormal metabolic reactions in skeletal muscle, liver, and adipose tissue. Impaired glucose control and insulin resistance reported being a risk factor for the development of cardiovascular disease.[3] IR commonly associated with glucose intolerance, hypertension, dyslipidemia, endothelial dysfunction and visceral adiposity contributes a significant pathophysiological role in type 2 diabetes.[4]

Insulin resistance and β-cell function arethe most frequently evaluated by using the measures like Fasting Insulin and Homeostatic Model Assessment-Insulin Resistance (HOMA-IR). Glucose clamp test does the gold standard tool for evaluation of insulin sensitivity.[5,6] Hyperglycemia is an early manifestation of development of diabetes which damages muscle and results in strength and mass loss leading to excess physical disability in older adults primarily in the lower extremity mobility tasks.[7]

Exercise and physical activityare considered as a cornerstone for the treatment and prevention of diabetes.[8] Exercise training is an essentialnon-pharmacological tool in the treatment of diabetes.[9,10] Aerobic and resistance exercise training improves the glycemic control by increasing insulin sensitivity and together shows a positive impact to improve glucose regulation and also helps to provide the synergistic effect.[10] Resistance training has shown more significant benefits in older patients with impaired glucose levels.[11]

Previous studies have reported that exercise intervention with eight weeks program achieved a beneficial impact on T2DM with increased cardiovascular fitness and reduced BMI.[8] In an earlier study, the type and duration of exercise had a more significant effect on the results. On the other hand, in most of the studies, the impact of use on insulin resistance has not been assessed enough. So, the current

research is aimed at evaluating the effects of a structured exercise program on insulin resistance in T2DM with peripheral neuropathy.

Material and Methods

The pre-post experimental study was conducted at the Diabetic Foot Clinic, Kasturba Hospital, Manipal, Karnataka, India and approved by the scientific committee and Institutional ethics committee of Manipal Academy of Higher Education, Karnataka, India. The study included 10 participants aged between 30-65 years who had T2DM with peripheral neuropathy. They were recruited using the purposive sampling method and were onoral hypoglycemic agents with or without Insulin therapy. Exclusion criteria for the study included participants with type 1 diabetes mellitus, known case of respiratory disease, coronary artery disease, neurological disorders, pregnant, people with thyroid disorders and musculoskeletal problems that would interfere with the exercise training and unwilling subjects. Informed consent was obtained after proper explanation of the study objectives to all the participants.

All participants were screened for insulin resistance and clinically, biochemically evaluated for fasting blood sugar and fasting insulin level. The test for the presence of the peripheral neuropathy (sensory and motor) was confirmed using 10g Monofilament test, Biothesiometer (Vibration Pressure Threshold).All participants with T2DMwere given a set of structured exercise program along with standard care. It mainly consisted of aerobic and resistance exercises like-brisk walking for 45 mins, jogging, weights for upper and lower body major muscle groups. The baseline data was collected before the intervention and during progression of exercise program at six weeks. At the 3rd month, all the participants were reassessed for fasting insulin level, Homa IR and fasting blood sugar.

Data analysis

SPSS version 16.0 software was used for statistical analysis. Independent t-test was used to compare the mean of all the outcome measures. Descriptive statistics are used to analyze the age, duration of diabetes, body mass index, and glycated hemoglobin and vibration perception threshold. Results were considered significant at $p < 0.05$ levels.

Results

Demographic characteristic data and parameters of all participants areshown in tables 1& 2. The current study aimed to find out the effectiveness of structured exercise program on insulin resistance, which demonstrated that the exercise programroved to be very useful. The study consisted of 10 participants comparable in age, gender and BMI. The average age of the participants was 58.80 ± 9.27. All the participants had a history of T2DM with a mean duration of 10.70 ± 6.29 years. Regular exercise is an essential non pharmacological tool. We designed and administered a structured exercise program for 12 weeks to participants with T2DM and evaluated its effects. In this study, the structured exercise program consists of aerobic, resistance exercises and flexibility which are given to the participants.

Table 1: Demographic characteristics of the study participants

S.No	Parameter	Mean ± SD
1	Age in years	58.80 ± 9.27
2	Duration of diabetes in years	10.70 ± 6.29
3	Body mass index	26.51 ± 2.38
4	Glycated hemoglobin (HbA1c) in %	8.18 ± 1.68
5	Vibration pressure threshold in volts	39.65 ± 10.57

Table 2: Demographic parameters of the study participants

S.no	Variable	Pre (mean ± SD)	Post (mean ± SD)	Mean difference (mean ± SD)	p value
1	Fasting insulin (mIU/L)	18.23 ± 7.66	11.78 ± 5.12	6.45 ± 3.99	0.001*
2	Homa IR	8.48 ± 3.52	3.84 ± 1.80	4.64 ± 2.29	0.005*
3	Fasting blood sugar (mg/dL)	187.40 ± 44.58	131.70 ± 14.46	55.70 ±40.61	0.002*
4	Post prandial blood sugar (mg/dL)	257.90 ± 69.85	201.90 ± 40.65	56.0 ± 46.69	0.004*

p value * - <0.05 ; SD=standard deviation

Discussion

In the current study, the participants who underwent a structured exercise program showed a mean decrease in fasting insulin and fasting blood sugar at post-intervention compared to pre-intervention. It is well documented that exercise training decreases

insulin resistance. The AHA, ADA, and ACSM recommend combined aerobic and resistance training for people with T2DM.[12]

There are several possible reasons proposed for improved glucose control following "prolonged exposure to exercise, which includes structural and biochemical adaptations of skeletal muscles. The former include supregulation of mitochondrial proteins involved in respiration -citrate synthase, increased glycogen synthase activity and GLUT4 protein content." The latter comprise resistance training-induced increase in contractile protein content, i.e., hypertrophy leading to a higher metabolic rate and in turn a potentially higher absolute glucose intake."

Aerobic exercise increases the distribution of substrates through increased proteins of mitochondria and improved muscle fiber capillary. Finally, visceral and intramuscular fat stores, i.e., regional adiposity, is directly proportional to the insulin insensitivity via a direct influence on insulin receptor function in muscle tissue by intramyocellular fat storage. The said decline may be due to increases in muscle mass as a result of resistance training, which in turn could contribute to blood glucose uptake without causing alterations in the intrinsic capacity of the muscle to respond to insulin. On the other hand, aerobic exercises enhance the insulin absorption through a higher action, independent of the changes in the muscle mass or aerobic capacity. A combination of aerobic and resistance exercise training may, therefore, be more effective in improving blood glucose control.[12] Earlier studies results had shown that participation in regular exercise by people with T2DM improves blood glucose control, reduce diabetes complications and have favorable effects on cardiovascular events, mortality, and quality of life.

Conclusion

Based on the results found in our study, participants with increased insulin resistance who underwent structured exercise program had significant improvement in values of fasting blood sugar and fasting insulin when compared with the control group, and these structured exercise program can be recommended to reduce insulin resistance in T2DM.

Acknowledgment

References

1. Motahari-Tabari N, Shirvani AM, Shirzad-e-Ahoodashty M, Yousefi-Abdolmaleki E, Teimourzadeh M. The Effect of 8 Weeks Aerobic Exercise on Insulin Resistance in Type 2 Diabetes: A Randomized Clinical Trial. *Glob J Health Sci* 2014;7(1):115-21.
2. Aune D, Norat T, Leitzmann M, Tonstad S, Vatten LJ. Physical activity and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis. *Eur J Epidemiol* 2015;30(7):529-42.
3. Short KR, Vittone JL, Bigelow ML, et al. Effect of supervised progressive resistance-exercise training protocol on insulin sensitivity, glycemia, lipids, and body composition in Asian Indians with type 2 diabetes. *Diabetes* 2008;67(7):179-83.
4. Gutch M, Kumar S, Razi SM, Gupta KK, Gupta A. Assessment of insulin sensitivity/resistance. *Indian J Endocrinol Metab* 2015;19(1):160-64.
5. Okita K, Iwahashi H, Kozawa J, et al. Homeostasis model assessment of insulin resistance for evaluating insulin sensitivity in patients with T2DMon insulin therapy. *Endocr J* 2013;60(3):283-90.
6. Singh B, Saxena A. Surrogate markers of insulin resistance: A review. *World J Diabetes*. 2010;1(2):36-47.
7. Kalyani RR, Metter EJ, Egan J, Golden SH, Ferrucci L. Hyperglycemia predicts persistently lower muscle strength with aging. *Diabetes Care* 2015;38(1):82-90.
8. Zou Z, Cai W, Cai M, Xiao M, Wang Z. Influence of the intervention of exercise on obese type II diabetes mellitus: A meta-analysis. *Prim Care Diabetes* 2015.
9. Lazarevic G, Antic S, Cvetkovic T, Vlahovic P, Tasic I, Stefanovic V. A physical activity programme and its effects on insulin resistance and oxidative defense in obese male patients with T2DMmellitus. *Diabetes Metab* 2006;32(6):583-90.
10. Fedewa M V, Gist NH, Evans EM, Dishman RK. Exercise and Insulin Resistance in Youth: A Meta-Analysis. *Pediatr* 2014;133(1):E163-E174.
11. Geirsdottir OG, Arnarson a., Briem K, Ramel a., Jonsson P V., Thorsdottir I. Effect of 12-week resistance exercise program on body composition, muscle strength, physical function, and glucose metabolism in healthy, insulin-resistant, and diabetic elderly Icelanders. *Journals Gerontol - Ser A Biol Sci Med Sci* 2012;67(11):1259-65.
12. Colberg SR, Sigal RJ, Fernhall B, et al. Exercise and type 2 diabetes: The American College Of Sports Medicine and The American Diabetes Association: Joint position statement executive summary. *Diabetes Care* 2010;33(12):2692-96.