Effect of Progressive Resistance Training along with Aerobic Training on Glycemic Control in Type 2 Diabetes

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Abstract

Background and Objective: Diabetes is a disease characterized by high blood glucose. About 220 million people have Type 2 Diabetes Mellitus (T2DM) in the world today.

Objective: To find out the effect of progressive resistance training along with aerobic exercise on glycemic control in type 2 diabetes.

Methods: 30 participants, who fulfilled selection criteria, were included in the study and they were randomly divided in two groups. Group A (n=15) performed the aerobic training and Group B (n=15) performed progressive resisted training along with aerobic training. Both groups were trained eight weeks of treatment consisting of five sessions weekly. HbA1c, BMI and SF 36 score were measured at baseline and posttest. Wilcoxon signed ranks test was used for the comparison between the pre and posttest values within the group and Mann Whitney U test was used for comparison between the pre and posttest values of the two groups.

Results: There is significant reduction in the HbA1c and improvement in BMI and SF 36 score (p< 0.05) in both the groups but group B shows more significant difference than group A.

Conclusion: The result of present study indicates that progressive resisted training along with aerobic training is effective on glycemic control in type 2 diabetes.

Keywords: Type 2 diabetes; Aerobic training; Progressive resisted training; Glycemic control

Introduction

Type 2 diabetes mellitus (T2DM) is insulin resistance in the muscle and liver cells in combination with insufficient ability of the β - cells in the pancreas to produce insulin. This will lead to enhanced blood glucose levels [1]. Epidemiology study shows that 220 million people have T2DM in the world today. In 15 years the number of people with T2DM is thought to be about 300 million [2]. According to WHO, the estimation of diabetes in 2030 in India and in South-east Asia region is 46,903,000 and 119,541,000 respectively [3]. India leads the world with largest number of diabetic subjects with termed diabetes capital of the world. Asian Indian Phenotype refers to certain unique clinical and biochemical abnormalities [4].

According to WHO an individual suffers from T2DM has fasting plasma glucose levels are above 7.0 mmol/lit or above 11.1 mmol/lit 2 hours after an Oral glucose tolerance test – OGTT [5]. Acquired conditions as obesity
and a sedentary lifestyle [6,7] seem to be important factors in the etiology of T2DM. Not only obesity but also body fat distribution around the waist increases the risk further to develop insulin resistance and T2DM [8,9]. Insulin resistances in adipose cells leads to an increase of lipolysis and increased levels of blood lipoproteins, so-called lipotoxity, which decreases insulin sensitivity further [10,11].

Influence of type 2 diabetes on exercise capacity is well known that maximal aerobic capacity is reduced in people with T2DM compared to matched controls. The aerobic capacity is reduced with 18-33% when measured relatively to the bodyweight [12,13] and with 13-17% not adjusted for body weight [14]. VO2 consumption during an incremental exercise test will be lower [12] and lactate production [15] higher at every single level of Waist ratio compared to matched controls. Slower HR response and consequently slower VO2 response to exercise has been seen in individuals with T2DM compared to normal and obese controls [13].

Now a day’s aerobic exercise, progressive resisted exercise were used to improve glycemic control. The American Diabetes Association (ADA) recommended that individual with type 2 diabetes should perform at least 150 min of moderate intensity aerobic exercise or at least 90 min of vigorous aerobic exercise per week. Aerobic exercise has consistently been shown to improve glucose control, enhance insulin sensitivity and reduce cardiovascular risk factors such as visceral adiposity, lipid profile, arterial stiffness and endothelial dysfunction [16]. Aerobic exercise should be performed at least 5 days/wk with no more than two consecutive days between bouts of activity because of the transient nature of exercise-induced improvements in insulin action [17].

Progressive resistance exercises are also effective on glycemic control. According to American college of sports medicine ACSM 2006, resistance exercise performed against an external force or load corresponding to an 8 to 12 repetition maximum (RM) be lifted in 1 to 3 sets, training 2 or 3 days each week is beneficial [17,18]. Activities that use muscular strength to move a weight or work against a resistive load include weight lifting and exercises using weight machines. When performed with regularity moderate to high intensity, resisted exercise increases muscular fitness. Increases in the protein content of the insulin receptor and kinase activity are evident in resistance-trained muscle, even without increases in lean mass, and may enhance glucose uptake, insulin receptor protein, and glycogen synthase activity [19].

Traditionally, aerobic activities have been recommended for people with type 2 diabetes because of the known benefits on insulin sensitivity and glucose tolerance. It is estimated that only 28% of individual’s with type 2 diabetes achieve these recommendations [19]. Recently, ACSM has recommended the use of progressive resistance training (PRT) as part of well-rounded exercise program for individual with diabetes. Resistance training improves insulin sensitivity and glycemic control. Several studies shown contradicting results whether progressive resistance training is effective or a combination of aerobic exercise plus progressive resistance training is effective to improve glycemic control. Hence the objective of this study is to compare the effect of aerobic training versus progressive resistance training along with aerobic training on glycemic control in type 2 Diabetes.

Methods and Materials

Trial Design

The study was an experimental study with a parallel group design conducted at C.U. Shah Physiotherapy College, Surendranagar, Gujarat, India. Recruitment period was January 2011 - December 2014 and the ethical approval was obtained from the Institutional and scientific ethical committee CUSPC/Ethical/146-A/11 and procedures followed the Declaration of Helsinki.

Subject Recruitment

Subjects were recruited by sending pamphlets to the various departments of the local medical college, hospitals and clinics. Subjects who had diagnosis of T2DM confirmed by physician, willing to participate in supervised exercise program, Age ≥40, Fasting plasma glucose ≥ 126 mg/dl and Glycosylated hemoglobin (A1c) value of ≥ 7% were included.

Individuals with severe obesity, arthritis, diabetes Complications, Coronary artery disease, uncontrolled hypertension, advanced retinopathy, neuropathy, Severe orthopedic/ cardiovascular/respiratory conditions restricting physical activity, Type 1 diabetes mellitus, and Gestational diabetes were excluded.

A total number of 48 subjects with type 2 diabetic were screened out of which (n=30) subjects were selected for the study. Each patient was screened initially by using a simple selection performa relevant to the inclusion and
exclusion criteria. Those who fulfilled this symptomatic criterion underwent a detailed assessment. Then the selected patients who were willing to participate were randomly divided into two groups of 15 each. The details and the purpose of the study were explained to all the subjects and informed consent was obtained from each subject.

Randomization

Randomization into groups was achieved through odd/even assignment, the first subject was assigned to Group A, the second subject was assigned to Group B, the third subject was assigned to Group A, the fourth subject was assigned to Group B, and so forth through the 29th being assigned to Group A and the 30th subject being assigned to Group B.

Data Collection

Subjects were explained about the Research and treatment protocol. Medical history, resting heart rate, blood pressure, and date of T2DM diagnosis, medications, and co-morbidities were collected. Subjects should be medically cleared for exercise by their primary care physician in the form a written prescription.

Outcome measures [baseline % HbA1c levels, Basal metabolic index - BMI & Short form SF-36] were collected before and after the program of 8 weeks of treatment. Group A (n=15) received aerobic training and Group B (n=15) received progressive resistance training along with aerobic training.

Outcome Measures

Percentage glycosylated hemoglobin (HbA1c): Hemoglobin A1c is measured at the Department of Clinical Biochemistry, Centre by HPLC - high-performance liquid chromatography method. Hemoglobin A1c (HbA1c) is a glycosylated derivative of hemoglobin and is one of a family of derivatives whose concentrations are elevated in patients with diabetes mellitus (Figure 1).

BMI: This was calculated as the weight (kg)/height (m²) (Figure 2).

SF (Short form) 36 questionnaire: All questions are scored on a scale from 0 to 100, with 100 representing the highest level of functioning possible. Aggregate scores are compiled as a percentage of the total point’s possible, using scoring table (Figure 3).

Treatment Protocol

The patients were divided into two groups, Group A was given Aerobic training and Group B was given progressive resisted training along with aerobic training. Each group had a warm up & a cool down program of before and after the prescribed exercise program respectively.

During week 1 to week 8 in both groups’ aerobic warm up and cool down was given with stretching of quadriceps, hamstring, and latissimus dorsi and calf muscle was given for 10 minutes.

In Group A aerobic training was given. In aerobic training walking 10 minutes, cycling 10 minutes, 2 minutes step up exercise and 3 minutes wand exercise was given. The exercise was given 3-5 days/week for 8 weeks with 50 - 40 % of heart rate reserve or corresponding to RPE 12 to 16 on 0 to 20 Borg scale. The exercises were given approximately 25-30 min and gradually increased 5 minutes every week.

In Group B progressive resisted training PRT along with aerobic training was given. In that resisted training was given to biceps (biceps curl), triceps (triceps extension), hamstrings (hamstring curl) and quadriceps (squatting) muscle. Abdominal crunches were also given, with rest interval of 30 seconds. The PRT was given 4 days/week according to repetition maximum - RM over the major muscle. All subjects in Group B completed the determination of 10 RM and they were trained according to De Lorme PRE method. All the major muscle were undergone the training of 10 repetition of 50% of 10 RM, 10 repetition of 75% of 10 RM, 10 repetition of 100% of 10 RM and the RM is increased 10 RM per week gradually.

Statistical Analysis

The statistical analyses were done using software called Statistical Package for Social Science (SPSS 18) for Windows. The statistical analyses used were descriptive analysis to find Means and standard deviation. Inter group comparison was analyzed by using non parametric Mann Whitney U test. Wilcoxon Signed Ranks Test was used for intra group Comparison of Group A and Group B.

Results

Mean and standard deviation were computed as measure of central tendency and measure of dispersion respectively. After analyzing the data with Mann-Whitney Test, the calculated U-value is greater than table U-value
and p value is ≥ 0.05, showing that there is no significant difference between pre values of HbA1c of BMI and SF-36 in Group A and B. After analyzing the data with Mann-Whitney test, the calculated U-value is lesser than table U-value and p value is ≤ 0.05, showing that there is significant difference between post values of HbA1c, BMI and SF-36 of Group A and B.

The mean and standard deviation of HbA1c, BMI and SF-36 of Group A were measured before the treatment (Pre), and after the treatment (post). The Mean and SD of pretest score of HbA1c, BMI and SF-36 is 8.14 ± 0.884, 29.57 ± 1.52, and 65.6 ± 7.81. The Mean and SD of post test score of HbA1c, BMI and SF-36 is 7.84 ± 0.488, 28.88 ± 2.08 and 67.93 ± 9.57. The Wilcoxon Signed Ranks test results shows that calculated Z-value is lesser than table Z-value and p-value is ≤0.05, showing that there is significant difference between pre and post values of HbA1c, BMI and SF-36 of Group A.

The mean and standard deviation of HbA1c, BMI and SF-36 of Group B were measured before the treatment (Pre), and after the treatment (post). The Mean and SD of pretest score of HbA1c, BMI and SF-36 is 8.13 ± 0.666, 30.65 ± 10.21 and 64.26 ± 1.20. The Mean and SD of post test score of HbA1c, BMI and SF-36 is 7.24 ± 0.601, 29.004 ± 10.27 and 68.46 ± 1.88. The Wilcoxon Signed Ranks test results shows that calculated Z-value is lesser than table Z-value and p-value is ≤0.05, showing that there is significant difference between pre and post values of HbA1c, BMI and SF-36 of Group B.

The inter group comparison was done by nonparametric independent sample Mann Whitney U Test for the comparison between Pre HbA1c, BMI and SF-36 of Group A and Group B, Post HbA1c, BMI and SF-36 of Group A and B. The level of significance was considered to be <0.05. Wilcoxon Signed Ranks Test was used for intra group comparisons of Group A and Group B i.e. between pre and post HbA1c, BMI and SF-36 of Group A, pre and post HbA1c, BMI and SF-36 of Group B (Table 1).

**Discussion**

The purpose of this study was to find out the additive effect of progressive resisted training along with aerobic exercise and aerobic exercise alone on glycemic control in type 2 Diabetes. The implication of the study may justify the additive effect of progressive resisted training along with aerobic exercise on glycemic control in type 2 Diabetes. The results found in this study disclosed that after an eight weeks treatment, both the groups attained...
a significant reduction in the HbA1c and an improvement in SF-36 score.

The outcome measures used were HbA1c, BMI and SF-36 score. The groups were synchronized with age and pretreatment scores of HbA1c (P=0.967), BMI (P=0.202), SF36 (P=0.461). All participants were treated with standardized programs. In group A its overall effectiveness on HbA1c, BMI and SF 36 Score was significant. This means that aerobic training is effective on glycemic control in type 2 diabetes. In group B its overall effectiveness on HbA1c, BMI, and SF 36 Score was also significant.

The intergroup comparison HbA1c, BMI and SF 36 Score showed significant effect after eight weeks of treatment in Group A and B. The literature on the effects of physical training on type 2 diabetes is comprehensive, but the mechanisms involved was dealt briefly here. Physical training enhances insulin sensitivity in the exercised muscle and enhances muscle contraction induced glucose uptake in the muscle.

Group A received Aerobic training alone and Group B received progressive resisted training along with Aerobic exercise once a day for 5 days a week for 8 weeks. Fourteen controlled trials with exercise interventions including aerobic exercise 3.4 times/week and resistance exercise 2.5 times/week for ≥ 8 weeks in adults with type 2 DM, reduced glycosylated hemoglobin (HbA1C) even with no significant change in body mass index (Boulé, Haddad, Kenny, Wells & Sigal, 2001) [20]. A meta-analysis conducted by Boulé, Kenny, Haddad, Wells and Sigal (2003) [21] concluded that as the intensity of physical activity increases, cardio respiratory fitness improved and HbA1C levels were reduced in patients with type 2 DM.

Resistance training as part of physical activity recommendations has been effective to improve glycemic control because induce the glucose uptake at cellular level in skeletal muscle and increase muscle strength. High-intensity resistance training programs decrease HbA1C levels [22], abdominal fat and systolic blood pressure and increase fat free mass [23]. Sigal et al. [24] conducted a randomized control trial and concluded that aerobic physical activity and resistance training improved HbA1C but glycemic control was greater if both activities were combined. In conclusion, physical activity is a valuable strategy for modifying risk factors in order to decrease diabetes incidence and diabetes chronic complications [25].

The results showed a significant decline in the HbA1c (P<0.001), a significant improvement in BMI (P<0.006) and a significant difference in SF 36 score (P<0.011) in the post treatment stage in comparison to the pretreatment stage. Both AT and PRT along with AT exercises reduced HbA1c and improvement in SF 36 score by comparing the post treatment variables in both A and B groups, the results revealed that there was significant improvement in group B than group A.

These findings are in accordance with Maiorana et al. [26] investigated the effect of an 8 week circuit training (CT) program, combining aerobic and resistance exercise, on indices of glycemic control, cardio respiratory fitness, muscular strength and body composition in 16 subjects and concluded that CT is an effective method of training that improved functional capacity, lean body mass, strength and glycemic control in subjects with type 2 diabetes [25].

Limitations of the study: The sample size is too small, where we cannot able to generalize the results. 8 week duration of training is not sufficient to get changes in BMI. Also there was no long-term follow-up of the patients after the study.

Recommendations for future study: The same study can be done with a longer follow-up and also using outcome measures like HDL, LDL and waist –hip ratio.
The study can be done on post-menopausal women and also can be done to see the changes in the cardiovascular risk factors.

**Conclusion**

The current study was conducted to find the effect and importance of progressive resisted training along with aerobic training in type 2 Diabetes. This study also provides the best exercise management for glycemic control in type 2 diabetes. It is noteworthy to mention that the result of present study indicates that progressive resisted training along with aerobic training is effective and beneficial on glycemic control in type 2 diabetes.

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**Ethical Approval**

The study received the ethical approval from Deanship of scientific research with reference number CUSPC/Ethical/146-A/11 and the study was conducted according to the ethical guidelines and principles of the Declaration of Helsinki.

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