

## Effects of progressive resistance training and aerobic exercise on type 2 diabetics in Indian population

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### Abstract

**Background and objective:** The Indian population faces a high risk for diabetes because of a high genetic predisposition and susceptibility to environmental insults. The objective of this study was to evaluate the effects of 16 weeks of Progressive resistance training (PRT) and Aerobic exercise (AE) on glycemic control, blood pressure, heart rate, muscle strength and control of type 2 diabetics. **Materials and Methods:** A total of 30 type 2 diabetics, 14 females and 16 males, aged between 40-70 years, were randomly assigned to the 16 weeks supervised PRT (n=10), or AE (n=10) or Control group (n=10). Pre- and post-outcome measures included glycosylated hemoglobin (HbA1c), fasting blood glucose (FBG), blood pressure (BP), heart rate (HR) and isometric muscle strength of the right hamstring and quadriceps muscles. **Results:** Plasma glycosylated hemoglobin levels decreased significantly ( $p=0.002$ ) both in the PRT ( $7.57 \pm 1.4$  to  $5.74 \pm 0.8$ ) and in AE group ( $8.11 \pm 0.9$  to  $6.78 \pm 1.3$ ). FBG decreased by 39.9% in PRT group by 14.3% in AE group and by 18.6% in the control group. PRT group exhibited significant reductions in blood pressure ( $p=0.002$  for systolic BP,  $p<0.001$  for diastolic BP) and heart rate ( $p=0.007$ ). Improvements in isometric muscle strength and balance were seen in both exercise groups. **Conclusion:** PRT is a more effective form of exercise training than AE for improving glycemic control, blood pressure and heart rate in type 2 diabetics.

**Key words:** Aerobic exercise, Progressive resistance training, Muscle strength, Glycosylated hemoglobin, Type 2 diabetes

### Introduction

The number of diabetics is rapidly rising all over the globe at an alarming rate and it is estimated that India will have 79.4 million diabetics by the year 2030<sup>1</sup>. An important factor contributing to the increasing number of type 2 diabetics in Asian Indians is high insulin resistance compared to Europeans which could be due to an environmental or genetic factor or a combination of both<sup>2</sup>. Endoplasmic reticulum (ER) stress could result in beta cell dysfunction and insulin resistance. The concept that 'the sustained ER stress of obesity, or chronic over-nutrition in the absence of obesity, can get transduced into increased insulin resistance' is significantly important for Indians as they experience total epidemiological diet transition.<sup>3</sup> Also type 2 diabetes is associated with changes in the diet patterns and decreased physical activity.<sup>4</sup> The burgeoning epidemic of type 2 diabetes mellitus is of grave concern because of its human and fiscal costs and the morbidity and mortality associated with the disease.

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.<sup>5</sup> Type 2 diabetics have an increased number of type II b muscle fibers, a low percentage of type

I fibers and a low capillary density. This abnormal muscle fiber composition may also affect tolerance for aerobic capacity.<sup>6</sup> Recently, the American College of Sports Medicine (ACSM) has recommended the use of progressive resistance training (PRT) as part of well rounded exercise program for individual with diabetes.<sup>6</sup> Resistance training improves insulin sensitivity and glycemic control.<sup>7,8</sup>

A review of literature suggests that in India the focus of research still remains at the level of the detection of diabetes, studies of complications and epidemiological data.<sup>3,4</sup> Recently, a study was done by Misra A *et al* on Asian Indians with type 2 diabetes to determine the effects of progressive resistance exercise (PRE),<sup>9</sup> but this study had some lacunae, such as the absence of a control group to compare with PRE, age group of patients was 25-50 years and no standardized PRE guidelines were followed. Randomized controlled trials to study the effects of modification of lifestyle factors including diet, physical activity and obesity have not been reported in the literature. Considering this fact, the primary aim of our study was to determine whether resistance training and aerobic exercises improve glycemic control and other outcome measures in the quality of life of type 2 diabetics. A secondary aim was to consider the economic implications and identify areas of future research.

### Materials and Methods

#### Subjects

A total of 30 subjects (14 females and 16 males) were recruited from University Health Centre, Guru Nanak Dev University, Amritsar, Punjab, India. All subjects gave their

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written informed consent to participate in the study. The study was given approval by Medical Ethics Committee of the University and was conducted during June to October, 2007. Inclusion criteria were as follows: established type 2 diabetes (> 6 months duration), an inactive lifestyle, no strength training in the preceding 1 year, not taking insulin, males or females aged between 40 to 70 years. Eligible subjects went under a physical examination and medical screening to exclude individuals with subjective or objective evidence of coronary artery disease, uncontrolled hypertension, advanced retinopathy or neuropathy, severe orthopedic/cardiovascular/respiratory conditions restricting physical activity. Subjects were then randomly assigned to one of the three groups: Progressive resistance training (PRT) Group, Aerobic exercise (AE) Group or Control group with each group having 10 subjects. Their descriptive characteristics are given in Table 1.

### Exercise Training protocol

**PRT Group:** The PRT subjects underwent training in accordance with American College of Sports Medicine (ACSM) guidelines,<sup>6</sup> two times per week. The training protocol consist of warm up (static cycling), resistance training phase and a cool down phase (static cycling). The resistance training phase included 3 sets of the following seven exercises: Biceps Curls, Triceps Curls, Front lateral pull down, back lateral pull down, Knee extension exercises on quadriceps table, Hamstring curls using quadriceps table and Abdominal curls. At 0 week, 1 RM (repetition maximum) was calculated for each exercise. Training started with 60% of 1 RM and was progressed to 100% of 1RM during the first 8 weeks of the training period. After 8 weeks, 1RM was assessed again and the intensity of exercises was again progressed from 60% of new 1RM to 100% for the next 8 weeks. Subjects performed 10 repetitions per set for all exercises. Total duration of training was 16 weeks.

**Aerobic exercise group:** Subjects performed walking as the aerobic exercise lasting for 16 weeks thrice a week with each session lasting 30 minutes.

**Control group:** Subjects went under no training but continued with their medications.

### Parameters

HbA1c (glycosylated haemoglobin), fasting blood glucose (FBG), blood pressure-systolic (SBP) and diastolic (DBP), heart rate (HR) and isometric muscle strength of the right hamstring and quadriceps muscles were measured at 0 week (before the training), after 8 weeks (mid training) and after 16 weeks of training (post training).

- HbA1c was analyzed using NycoCard HbA1c test (NycoCard reader II, Axis Sheild PoC, made in Norway).
- Fasting blood glucose (FBG) was determined by glucometer (Elegance CTX-10).
- Blood pressure was measured using Lifecare™ Sphygmomanometer (N&B Medical Products Co., India).

- Heart rate was measured using Polar S410™ heart rate monitor, CE0537 (Finland)
- Muscle Strength: Isometric strength of the right quadriceps and hamstring muscles was measured using HUR isotonic/isometric dynamometer software (University of Helsinki, Finland). Research line 2.0 was used for isometric data collection. The torque was measured at 10 second isometric hold and 60° knee flexion for quadriceps and at 40° knee flexion for hamstrings. It was normalized to force by dividing torque by lever arm length. Peak force and average force (average of four quarters, 1 quarter =2.5 sec; for 10sec) was calculated.
- Balance: Balance in all subjects was assessed using Berg balance scale score (BBSS).

**Statistical Analysis:** Results are reported as group mean  $\pm$  standard deviation. Initial baseline measurements were analyzed by ANOVA to determine differences between the groups before intervention. The changes post training were compared between groups by ANOVA. Post hoc analysis was done using the Scheffé's test when applicable. Statistical tests were performed using SPSS Software (SPSS 14.0, free evaluation version). Statistical significance of the change in results, from pre-study to the post-study is indicated at  $P \leq 0.01$  level.

### Results

In the present study, there was one dropout in the PRT group due to time constraints. No exercise related injuries and hypoglycemic events were reported.

**Glycemic control:** The two exercise groups showed significant reduction ( $p=0.002$ ) in HbA1c levels (PRT group: 24.2% decrease, AE group: 16.4% decrease) compared with control group (2.8% decrease) as shown in Table 2. After 16 weeks of training, FBG decreased significantly ( $p=0.021$ ) by 39.9% in PRT group and by 14.3% in the AE group when compared to the 18.6% decrease in the control group as shown in Table 2.

**Blood pressure and heart rate:** Systolic and diastolic blood pressure showed significant ( $p=0.001$ ) reduction by 7.1% and 9.7%, for SBP and DBP, respectively in PRT group. AE group showed 1-2% decrease in BP as shown in Table 2.

**Table 1:** Descriptive characteristics (mean  $\pm$  SD) of the study group

	Control group	PRT Group	AE Group
Numbers(M/F)	10(6M, 4F)	10(4M, 6F)	10(6M, 4F)
Age ( in years)	58.4 $\pm$ 1.8	49.6 $\pm$ 5.2	52.2 $\pm$ 9.3
Duration of diabetes(years)	5.2 $\pm$ 2.9	5.4 $\pm$ 1.5	4.7 $\pm$ 1.7
BMI	24.98 $\pm$ 3	26.99 $\pm$ 4.1	26.23 $\pm$ 3.2
HbA1c (%)	7.77 $\pm$ 0.3	7.57 $\pm$ 0.5	8.11 $\pm$ 0.3
Number of participants treated with			
Diet only	0	2	4
Oral Drugs	10	8	6

**Table 2:** Changes in the glycemic control, blood pressure, heart rate, muscle strength and balance (mean  $\pm$  SD) in all the three groups

Parameter	Control group, 0 week	Control group, 16 weeks	PRT group, 0 week	PRT group, 16 weeks	AE group, 0 week	AE group, 16 weeks
HbA1c (%)	7.77 $\pm$ 0.9	7.56 $\pm$ 0.9	7.57 $\pm$ 1.4	5.74 $\pm$ 0.8*	8.11 $\pm$ 0.9	6.78 $\pm$ 1.3*
FBG (mg/dl)	191 $\pm$ 59.1	161 $\pm$ 52.2	173 $\pm$ 35.9	104 $\pm$ 12.2	182 $\pm$ 33.6	156 $\pm$ 54.2
SBP (mm of Hg)	131 $\pm$ 6.4	133 $\pm$ 8.9	126 $\pm$ 6.8	117 $\pm$ 4.6*	132 $\pm$ 8.5	129 $\pm$ 11.6
DBP (mm of Hg)	84 $\pm$ 4.4	85 $\pm$ 3.8	82 $\pm$ 3.6	74 $\pm$ 3.7*	84 $\pm$ 5.3	83 $\pm$ 7.4
HR (Beats/min)	84 $\pm$ 5.3	85 $\pm$ 3.8	90 $\pm$ 8.3	74 $\pm$ 3.8*	87 $\pm$ 6.8	85 $\pm$ 5.4
Peak extension force (N)	188.5 $\pm$ 58.7	175.9 $\pm$ 58.1	185.6 $\pm$ 86.4	237.6 $\pm$ 116.7	169.1 $\pm$ 86.4	229.1 $\pm$ 62.5
Mean extension force (N)	162.9 $\pm$ 51.6	154.8 $\pm$ 48.9	165.2 $\pm$ 82.8	201.4 $\pm$ 98.6	163.7 $\pm$ 49.4	199.5 $\pm$ 54.8
Peak flexion force (N)	125.4 $\pm$ 51.6	111.7 $\pm$ 55.2	130.5 $\pm$ 43.5	164.2 $\pm$ 46.9*	137.1 $\pm$ 48.5	168.1 $\pm$ 52.8*
Mean flexion force (N)	108.2 $\pm$ 4.8	107.8 $\pm$ 40.7	115.5 $\pm$ 41.8	139.6 $\pm$ 42.7	117.6 $\pm$ 50.2	137.9 $\pm$ 47.2
BBSS	50 $\pm$ 2	50 $\pm$ 2	51 $\pm$ 1	54 $\pm$ 0.7	50 $\pm$ 2	53 $\pm$ 1.3

Note that HbA1c decreased significantly ( $p < 0.01$ ) 16 weeks after PRT and AE. The systolic and diastolic blood pressure decreased significantly ( $p < 0.01$ ) in PRT and AE groups compared to control. Only the PRT group showed significant decrease in heart rate. PRT and AE was associated with a significant increase in muscle strength. PRT = Progressive resistance training; AE= Aerobic training, BBSS = Berg balance scale score.

There was significant reduction in heart rate by 17.8% in PRT group as compared to 2.3% decrease and 1.2% increase in AE and control group, respectively.

**Muscle strength and balance:** Although there was an increase in isometric strength of the right quadriceps and hamstring in both the exercise groups (Table 2), only peak flexion force was statistically significant ( $p < 0.01$ ). Control group showed a decrease in muscle strength. There was around 6% improvement in balance in both PRT and AE group, which was significant  $p < 0.001$  higher compared to control group (Table 2).

### Discussion

We analyzed the effects of PRT and AE on glycemic control, blood pressure, heart rate, muscle strength and balance in an Indian population with type 2 diabetes. The principal findings include the following: PRT and AE elicited significant improvements in all parameters as compared to the control group, but the current findings strongly suggest that PRT is a more effective form of exercise training than AE for improving glycemic control, blood pressure and heart rate in type 2 diabetics in an Indian population.

The improvement seen in glycemic control as shown in Table 2 can be explained on the basis that physical training improves insulin action predominantly in skeletal muscle. The mechanism behind this phenomena include several adaptations like increased capillary density and GLUT4 content, a shift towards more insulin sensitive fiber types, possibly changes in the phospholipids composition of the sarcolemma, increase glycolytic and oxidative enzymatic activity and increase in glycogen synthase activity<sup>10</sup>.

Exercise causes an increase in glucose uptake in skeletal muscle and also an increase in 5'AMP- activated protein kinase (AMPK) activity which is due to an increase in translocation in GLUT4 to surface membranes.<sup>11</sup> Also activation of AMPK enhances glucose transport through increased cell surface GLUT 4 content in insulin resistant skeletal muscle<sup>12</sup> and mediates the effects of GLUT4 expression.<sup>13</sup>

Moreover, we found that the average mean values of HbA1c after 16 weeks of training in PRT group were 5.7% which is within the normal range of HbA1c (4 to 5.9%).<sup>14</sup> Even in the AE group, we reported a decline in the average HbA1c values to 6.78%, which is below 7%, the target goal for diabetes according to ADA.<sup>15</sup> HbA1c is an important indicator of glycemic control. Studies have shown that establishing good glucose control at or below 7% can reduce the long term complications by up to 76%.<sup>16</sup>

It should be highlighted that the improvement seen in blood pressure and heart rate in PRT group in our study signify the improved cardiovascular risk factors such as hypertension and elevated fibrinolytic activity. Chronic PRT is shown to reduce acute SBP and DBP and rate pressure product response to weight lifting by 17-27%.<sup>17</sup> Hence, it is becoming evident that exercise can reduce the need for medication as the risk factors and glycemic control improves. For the first time, we report that 57% of the participants in the PRT group showed 50% reduction in their medication dose with 16 weeks of training in Indians with type 2 diabetes whereas no such change was observed in either the AE group or control group. According to WHO, overall, direct health care costs of diabetes range from 2.5 to 15% of annual health care budgets, depending on the local diabetes prevalence and the sophistication of

the treatment available.<sup>18</sup> Because of its chronic nature, the severity of its complications and the means required to control them, diabetes is a costly disease, not only for the affected individual and their families, but also for the health systems. Studies in India estimate that, for a low-income Indian family with a diabetic adult, as much as 25% of family income may be devoted to diabetes care.<sup>18</sup>

In India, only a budget of 2% is allocated for the Health Care System by the government. Considering a rather low estimate of approximately 20 million diabetic patients in India, the annual estimated cost could be as much as 2 billion USD for diabetes health care.<sup>19</sup> Hence, it is reasonable to presume that any treatment modality that decreases this cost will be considered beneficial and the results of our study indicate that PRT is one such modality.

Although the balance and mean extension force improvement seen in both the exercise groups were same, there was difference in peak extension force improvement (35.5% in AE group and 27.5% in PRT group). This may be due to individual variations. Improvement in muscle strength is very important in diabetics as reported in our study, because there is graded association between increased glucose levels, weaker muscle strength and impaired physical function.<sup>20</sup> Also individuals with diabetes have less muscular strength than their age-matched counterparts, possibly due to peripheral neuropathy and reduced vascular supply compounding muscle atrophy and weakness of age and further compromising insulin sensitivity and glycemic control. Not much difference was seen in strength between PRT and AE which can be attributed to the fact that no specific squatting activities were included in the PRT program and it is reasonable to presume that there was more generalized increase in lean body mass in the subjects in PRT group.

In summary, the current findings demonstrate that PRT is a safe and viable option for the management of type 2 diabetes. It will be a cornerstone method in economically managing type 2 diabetes in India thus reducing the economic burden of the diabetes capital of the world.

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