# EFFECT OF PROGRESSIVE RESISTANCE TRAINING ON GLYCEMIC CONTROL IN ELDERLY TYPE II DIABETIC PATIENTS

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## ABSTRACT

***Objective:*** *To investigate the effect of progressive resistance training (PRT) on glycemic control in elderly type II diabetic patients.*

***Methodology:*** *The study was conducted on 40 elderly individuals with type II diabetes. They were divided into 2 equal groups. The progressive resistance training (PRT) group received 16 weeks of PRT program plus the usual diabetic care, while the control group received a controlled exercise program plus the usual diabetic care. Glycemic control, lipid profile, resting blood pressure, muscle strength and anthropometry were evaluated for the 2 groups at baseline and at end of the study.*

***Results:*** *For the PRT group we found a highly significant reduction in glycosylated hemoglobin level (HbA1c) ($t=13.64$, $p<0.001$), highly significant increase in muscle strength ($t=10.19$, $p<0.001$), trend for reduction in blood pressure and trend for reduction in triglyceride level.*

***Conclusion:*** *PRT when included with usual diabetic care for elderly people with type II diabetes is of benefit in glycemic control and at the same time is safe and well tolerated.*

## INTRODUCTION

Exercise, along with diet and medication, plays an important role in management of type II diabetes. Aerobic or endurance exercise programs have been traditionally recommended for elderly patients with type II diabetes and have been associated with weight loss, improved glucose tolerance, and cardiovascular fitness *(Tessier et al., 2000).* However, most forms of aerobic exercise would not be advisable with advanced peripheral

neuropathy and in people with severe obesity. On the other hand, resistance exercise training, by increasing muscle mass and endurance, often causes more rapid changes in functional status and body composition than aerobic training. Also, resistance exercise improves insulin sensitivity to about the same extent as aerobic exercise *(Ivy, 1997).* Because of the increased evidence of health benefits from resistance training during the past 10-15 years, the American College of Sports Medicine (ACSM) recommended resistance training be included in fitness programs for adults with type II diabetes *(ACSM, 1998).* Its use in diabetes is supported by the American Diabetes Association (ADA) although not in elderly individuals or individuals with long-standing diabetes *(ADA, 2001).* However, the reasons given by the ADA for these exclusions are considered by some authors, vague and not supported by scientific justification *(Karen et al., 2003).* Due to the limited information on the role of resistance training for older patients with type II diabetes, it has been recommended that resistance training programs use moderate weights and high repetitions *(ADA, 2001).*

However, it appears that the impact of progressive resistance training on muscle mass and strength in both young and old individuals is more pronounced if higher training intensities (70-90% of the one repetition maximum (1-RM) are used *(Fielding, 1995).* With increased age, there is a tendency to progressive decline in muscle mass, decreased functional capacity, decreased resting metabolic rate, increased adiposity, and increased insulin resistance, and resistance training can have a major positive impact on each of these *(ACSM, 1998).*

### Aim of the study:

The aim of the present study was to investigate the effects of 16 weeks of progressive resistance training program on glycemic control in elderly adults with type II diabetes.

## SUBJECTS AND METHODS

The present study involved men and women with treated (diet and/or medication) type II diabetes mellitus. Inclusion criteria included: age > 55 years, over weight [Body mass index (BMI) > 27 Kg/m² and ≤ 40 Kg/m²], established (> 6 months) but not optimally controlled type II diabetes [glycosylated hemoglobin (HbA1c) range 7-10%], no strength training in the preceding 6 months and not currently using insulin.

Seventy potential volunteers were subjected to: thorough medical history, physical examination, resting blood pressure measurement, HbA1c estimation and maximal graded exercise tolerance test with electromyogram monitoring. Eighteen out of the 70 subjects were excluded. Exclusion reasons included: subjective or objective evidence of ischemic heart disease,

uncontrolled hypertension (> 160/90), advanced diabetic neuropathy, severe orthopedic disease, any unstable chronic condition including dementia, dialysis, and retinal hemorrhage or detachment. Also we excluded subjects with any contraindication for resistance training as outlined by *Fiatarone, (2000).*

Forty-eight patients out of the 52 who met the entry criteria agreed to enter the study. Subjects were then randomly assigned to one of 2 groups:

The study group (PRT group) were subjected to usual care + progressive resistance training program.

The control group were subjected to usual care + control exercise program.

## I- Clinical and laboratory measurement:

A) Resting: supine blood pressure monitor: 3 readings were recorded at 1-minute interval, and the mean was recorded. Blood pressure was measured at baseline and 24 hours after the last exercise session.

B) Anthropometry: height (cm) was measured using stadiometer body weight (kg) was assessed using electronic scale and BMI was calculated according to the formula:

$$BMI = \frac{\text{Weight (kg)}}{[\text{Height (meter)}]^2}$$

Waist circumference was measured using a non0elastic measuring tape at the midpoint between the lower border of the ribcage and the iliac crest.

c) Venous blood samples were drawn by antecubital vein puncture following overnight fasting to determine:

HbA1c by immunoturbidemetric method on cobas-integra 400, glucose by hexokinase method on cobas-integra 400, insulin by microparticle enzyme immunoassay (MEIA) on axsym, cholesterol by enzymatic colorimetric method (CHOD/PAP) on cobas-integra 400, and triglyceride by enzymatic colorimetric method (GPO/PAP) on cobas-integra 400. Laboratory measurements were done at baseline and 48 hours following the last exercise session.

## II-Muscle strength:

1-RM was defined as the maximum amount of resistance that could be moved through the full range of motion of an exercise for no more than one repetition. 1-RM which was assessed for each exercise or machine used for training and muscle strength, was calculated as the sum of 1-RM

measures. Muscle strength was evaluated at baseline and following the last exercise session.

### III- Exercise intervention (according to Dunstan et al., 2002):

During the 16 weeks duration, all study subjects attended exercise sessions on 3 non-consecutive days/week. All sessions were supervised.

**a) For PRT group:** subjects followed an individually monitored PRT program using free weights and a multiple-station weight machine. Nine exercises were used for training: bench press, leg extension, upright row, lateral-pull down, standing leg curl (ankle weights), dumbbell seated shoulder press, dumbbell seated biceps curl, dumbbell triceps kickback and abdominal curl. All subjects were required to perform each repetition in a slow, controlled manner with a rest of 90-120 seconds between sets. Three sets of 8-10 repetitions were performed for all exercises at each training session (except for abdominal curl). Training work load was increased regularly as tolerated for each muscle group after the subject has successfully achieved three sets of 10 repetitions. The goal was to reach 75-85% of baseline 1-RM starting with 50-60% of each individual's 1-RM. Each training session consisted of 5 minutes warm-up and 5 minutes cool-down period of low-intensity stationary cycling and 45 minutes of resistance training.

**b) For the control group:** Control exercise program consisted of stationary cycling with no work bad for 5 minutes, followed by 30 minutes of series of static stretching exercises to improve flexibility with no change in muscle strength or cardiovascular fitness.

All study subjects continued their antidiabetic and antihypertensive medications throughout the study and were recommended to follow diet prescribed by their health providers.

### Statistical analysis:

Analysis of data was performed with an IBM compatible computer using SPSS 8 for Windows (Statistical Package for the Social Sciences). Descriptive statistics were done for continuous variables by mean, standard deviation (SD) and range, for qualitative data by number and percent. Analytic statistics were done using Student's t test to compare two independent means.

## RESULTS

Eight out of the 48 patients who started the study did not continue the 16 weeks duration for different reasons which did not include any adverse effects or injuries related to exercise program and were excluded from statistical analysis

There was no difference at base line between PRT group and the control group (table 1).

Table (1): Descriptive characteristics of PRT and control groups at baseline.

| Variable | PRT group No./ Mean ± SD | Control group No./ Mean ± SD |
|---|---|---|
| Number | 20 | 20 |
| Age | 60 ± 2 | 59 ± 9 |
| Sex (female/male) | (13/7) | (14/6) |
| Diabetes duration (years) | 6.3 ± 0.4 | 7.1 ± 0.9 |
| Oral hypoglycemic medication use | 18 | 17 |
| Antihypertensive use | 14 | 13 |
| **Anthropometry:** | | |
| • Height (cm) | 159.8 ± 8.7 | 160 ± 9.1 |
| • Weight (kg) | 82.7 ± 10.9 | 83.5 ± 12.1 |
| • BMI (kg/m$^2$) | 31.5 ± 1.5 | 32.5 ± 2 |
| • Waist circumference (cm) | 103.3 ± 7.5 | 101.3 ± 11.4 |
| Systolic blood pressure(mmHg) | 137.2 ± 3.4 | 139.4 ± 3.9 |
| Diastolic blood pressure(mmHg) | 70.6 ± 3.5 | 69.8 ±1.3 |
| Fasting plasma glucose (mg/dL) | 170 ± 2 | 170.6 ± 3 |
| Fasting insulin (pmol/L) | 132.9 ± 23 | 138.9 ± 25.8 |
| HBA1c (%) | 8.7 ± 0.3 | 8.9 ± 0.3 |
| Triglycerides (mg/dL) | 168 ± 5.3 | 171.9 ± 0.3 |
| Total cholesterol (mg/dL) | 198.86 ± 0.18 | 189.7 ± 0.18 |
| HDL (mg/dL) | 46.1 ± 2.1 | 46.8 ± 0.2 |
| LDL (mg/dL) | 104.7 ± 3.18 | 102.9 ± 3.15 |
| Muscle strength (kg) | 389 ± 30 | 351 ± 31 |

As shown in table 2 and table 3 there was highly significant improvement in HbA1c level in PRT group when compared to control group ($t=9.97$, $p<0.001$ ) and when compared to baseline level ($t= 13.64$, $p<0.001$).

By the end of the study non significant difference was found between PRT group and control group (table 2) as regards glucose level ($t=2$, $p>0.05$) and insulin level ($t=0.27$, $p>0.05$) and when they were compared to base line values (table 3), non significant difference was also found for both PRT group ($t=0.65$, $p>0.05$) and control group ($t=0.058$, $p>0.05$).

Total high density lipoprotein (HDL), low density lipoprotein (LDL), cholesterol and triglyceride levels did not change between the 2 groups (table 2) and from base line (table 3). However there was a trend toward reduction in triglyceride level in PRT group when compared to control group (table 2) although this difference did not reach a statistical significance ($t=2.34$, $p>0.05$).

Although non significant difference was obtained between the 2 groups regarding systolic and diastolic blood pressure (table 2), reduction in both measurements was noticed for PRT group (table 3).

Body weight and waist circumference did not change between the 2 groups (table 2) and also did not change from base line (table 3).

We found a significant increase in muscle strength for PRT group only (table 3); while for the control group reduction in muscle strength was noted (table 3).

Table (2): Clinical and laboratory parameters for PRT and control groups following the 16 weeks study.

| Variable | PRT group | Control group | t | p | Sig. |
|---|---|---|---|---|---|
| Body weight (kg) | 84.9 ± 2 | 85.5 ± 1.5 | 1.07 | >0.05 | NS |
| Waist circumference (cm) | 102 ± 3.5 | 103.1± 1.5 | 1.29 | >0.05 | NS |
| Systolic blood pressure<br>Diastolic blood pressure (mmHg) | 135.5± 3.3<br>69.2 ± 1.2 | 137.1± 3.5<br>69.8 ±1.3 | 1.95<br>1.52 | >0.05<br>>0.05 | NS<br>NS |
| Fasting plasma glucose (mg/dL) | 169.6 ± 0.4 | 169.4 ± 0.2 | 2 | >0.05 | NS |
| Fasting insulin (pmol/L) | 125.8 ± 43.3 | 130.4 ± 60.3 | 0.27 | >0.05 | NS |
| HbA1c (%) | 7.6 ± 0.2 | 8.8 ± 0.5 | 9.97 | <0.001 | HS |
| Triglycerides (mg/dL) | 165 ± 5.4 | 170.2 ± 6.5 | 2.34 | >0.05 | NS |
| Total cholesterol (mg/dL) | 194.78 ± 7.2 | 190.6 ± 6.3 | 1.95 | >0.05 | NS |
| HDL (mg/dL) | 47.5 ± 2.4 | 47.1 ± 2.2 | 0.55 | >0.05 | NS |
| LDL (mg/dL) | 102.6 ± 4.13 | 104.9 ± 4.66 | 1.65 | >0.05 | NS |
| Muscle strength (kg) | 518 ± 48 | 348 ± 30 | 13.43 | <0.001 | HS |

NS: non significant, HS: highly significant.

Table (3): Comparison between baseline and post study values of clinical and laboratory parameters for PRT and control groups.

| Variable | | PRT group | t | p | Control group | t | p |
|---|---|---|---|---|---|---|---|
| Body weight (kg) | Baseline | 82.7 ± 10.9 | 0.88 | >0.05 NS | 83.5 ± 12.1 | 0.73 | >0.05 NS |
| | Post study | 84.9±2 | | | 85.5±1.5 | | |
| Circumference of waist (cm) | Baseline | 103.3 ± 7.5 | 0.7 | >0.05 NS | 101.3 ± 11.4 | 0.7 | >0.05 NS |
| | Post study | 102±3.5 | | | 103.1±1.5 | | |
| Systolic blood pressure (mmHg) | Baseline | 137.2 ± 3.4 | 1.6 | >0.05 NS | 139.4 ± 3.9 | 1.96 | >0.05 NS |
| | Post study | 135.5±3.3 | | | 137.1±3.5 | | |
| Diastolic blood pressure (mmHg) | Baseline | 70.6 ± 3.5 | 1.69 | >0.05 NS | 70.1 ± 2.1 | 0.54 | >0.05 NS |
| | Post study | 69.2±1.2 | | | 69.8±1.3 | | |
| Fasting plasma glucose (mg/dL) | Baseline | 170 ± 2 | 0.88 | >0.05 NS | 170.6 ± 3 | 1.78 | >0.05 NS |
| | Post study | 169.6±0.4 | | | 169.4±0.2 | | |
| Fasting insulin (pmol/L) | Baseline | 132.9 ± 23 | 0.65 | >0.05 NS | 138.9 ± 25.8 | 0.58 | >0.05 NS |
| | Post study | 125.8±43.3 | | | 130.4±60.3 | | |
| HbA1c (%) | Baseline | 8.7 ± 0.3 | 13.64 | <0.001 HS | 8.9 ± 0.3 | 0.77 | >0.05 NS |
| | Post study | 7.6±0.2 | | | 8.8±0.5 | | |
| Triglycerides (mg/dL) | Baseline | 168 ± 5.3 | 4.96 | >0.05 NS | 171.9 ± 0.3 | 1.17 | >0.05 NS |
| | Post study | 165 ± 5.4 | | | 170.2±6.5 | | |
| HDL (mg/dL) | Baseline | 46.1 ± 2.1 | 1.96 | >0.05 NS | 46.8 ± 0.2 | 0.61 | >0.05 NS |
| | Post study | 47.5±2.4 | | | 47.1±2.2 | | |
| LDL (mg/dL) | Baseline | 104.7 ± 3.18 | 1.8 | >0.05 NS | 102.9 ± 3.15 | 1.59 | >0.05 NS |
| | Post study | 102.6±4.13 | | | 104.9±4.66 | | |
| Muscle strength (kg) | Baseline | 389 ± 30 | 10.19 | <0.001 HS | 351 ± 31 | 0.31 | >0.05 NS |
| | Post study | 518±48 | | | 348±30 | | |

NS: non significant, HS: highly significant.

# DISCUSSION

Improvement in glycemic control perse, irrespective of the means of attaining this, is the critical factor in reducing the risk of chronic diabetic complications. Because skeletal muscle is the biggest reservoir for glucose disposal and muscle wasting from aging exacerbate problems of peripheral glucose uptake. Muscle weakness, decreased muscle mass, decreased activation of glycogen synthase, and change in type II B skeletal muscle fiber numbers are related to and may precede insulin resistance, glucose intolerance and type II diabetes *(AlBright et al., 2000).* Individuals with diabetes have less muscular strength than age – matched counterpart due to peripheral neuropathy and diminished vascular supply, compounding the muscle atrophy and weakness of age and further compromising insulin sensitivity and glycemic control *(Dunstan et al., 2002).*

At base line, all our study subjects had poor glycemic control as shown by high HbA1c level (table 1). Following the 16 weeks study only the PRT group showed highly significant reduction in HbA1c when compared to base line level (table 3) ($p<0.001$). This reduction is of great advantage regarding type II diabetes prognosis. This is supported by recent data from the EPIC- Norfolk prospective population study *(Khaw et al., 2001),* which confirmed that HbA1c concentration explained most of the excess mortality risk of type II diabetes.

Our reported inverse association between HbA1c and muscle strength in PRT group suggests that resistance training reduce hyperglycemia by eliciting glucose uptake at the cellular level in skeletal muscle, where the biggest proportion of glucose uptake takes place *(Cartee, 1994).* The reduction of HbA1c level was not associated with change in body weight. This supports the opinion that exercise alone, in absence of any change in body weight, is able to significantly enhance insulin sensitivity and glucose homeostasis *(Boule et al. 2001).* Our reported improvement in glycemic control with PRT in older patients with type II diabetes have also been demonstrated by *Dunstan et al. (2002) and Castaneda et al. (2002).* Dunstan and his associates found that after 6 months of high intensity PRT (75 - 80 % 1-RM ) combined with moderate energy restriction in 29 older over weight sedentary subjects with type II diabetes, there was a significant reduction in HbA1c from base line (-1.21±0.2%) compared to diet alone and control groups. In the other study, Castaneda and his colleagues conducted a study on 43 older Hispanic subjects with type II diabetes , 16 weeks of high intensity PRT significantly improved HbA1c when compared to non exercising control group (-1.0 ± 1.1% vs. 0.4 ± 1.2% respectively; $p = 0.0001$). On the other hand (Dunstan et al. 2002) showed non significant effect on HbA1c following 8 weeks of

circuit training in type II diabetes patients. In a similar study *(Maiorana et al. 2002)* following 8 weeks of circuit training mean HbA1c was 8.5 % following sedentary periods and 7.9% following exercise periods. However, both studies shared two limitations: first, insufficient duration of the intervention, because 3-6 months of training are required for significant muscle hypertrophy *(Baechle & Earle, 2000)*, second, the mixed resistance and aerobic training design of their studies precluded distinguishing the independent effects of each modality *(Ronald et al., 2004).*

The present study showed non significant change for fasting glucose and insulin levels when compared to base line values for both groups (table 3). This result was similarly obtained by *Castaneda et al. (2002).* The explanation may be that in both studies blood sample was taken 48 hours following the last exercise session while improved insulin sensitivity after exercise training in type II diabetes may be due to the cumulative effects of the individual acute exercise bout (Schneider et. al., 1984), or because major effects of resistance training programs was on postprandial (not fasting) glucose and insulin levels *(Dunstan et al. 2002).*

By the end of our study non significant difference was obtained between the 2 groups as regards waist circumference. This implies that mechanisms other than abdominal obesity changes have been involved in the more pronounced effect on HbA1c observed after PRT *(Dunstan et al., 2002).* We found that total HDL and LDL cholesterol level did not change between the 2 groups, although there was a trend toward a reduction in serum triglyceride levels in PRT group compared to control group. This result was similar to that obtained *by Dunstan et al. (2002) and Castaneda et al. (2002).* Common to all these studies, resistance training has not altered body weight during the intervention period, and this suggests that a greater change in body weight may be necessary to have a significant effect on lipid profile after resistance training.

There was a trend of both systolic and diastolic blood pressure to fall (when compared to baseline values) with PRT; however, this change did not reach a statistical significance (table 3). This finding is consistent with other studies conducted on patients with type II diabetes *(Dunstan et al., 2002, Dunstan et al., 1997 and Maiorana et al., 2002).* These studies supported the safety of PRT in older individuals with hypertension and type two diabetes.

*MacDougall et al. (1985)* found that large brief pulsatile swings in arterial blood pressure throughout each repetition at high intensity resistance training, and peak arterial blood pressure rose over a set of repetitions; however these effects were transient returning to baseline values or even below 1-2 seconds after the final lift. *McCartney (1999)* mentioned that the

higher diastolic pressure with PRT ensured a more prolonged coronary artery filling at a higher perfusion pressure than aerobic exercise which was of potential benefit to older individuals, particularly those with diastolic dysfunction or coronary artery disease. Consistent with this are reports of patients who exhibited ischemia or angina during treadmill work but not during PRT, additionally, ischemic signs and symptoms were reduced after PRT in cardiac patients, attesting to its safety even in high risk individuals *(Benn et al., 1996),* with no clinically significant fatal or non fatal cardiovascular events reported in over 26,000 maximal strength tests performed *(Gordon et al., 1995).*

## Conclusion:

PRT in elderly patients with type II diabetes, when included with their usual care, could help in glycemic control, improves muscle strength, and at the same time is safe and well tolerated. Further studies are needed to support our suggestion.

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