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The Effect of Supervised Progressive Resistance Training (PRT) on Glycemic Control and Cardio Vascular Disease (CVD) Risk Markers in Type 2 Diabetes Patients, North West Ethiopian

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Abstract

Background: The effect of resistant exercise program on controlling metabolic abnormality and improving chronic complication risk factors has not been extensively studied in Type 2 Diabetes Mellitus patients in Ethiopian context.

Objective: The objective of this study is to determine the effect of supervised Progressive Resistance Training (PRT) protocol on weight loss, body composition, glycemic control and cardio vascular disease (CVD) risk markers reduction to prevent and control Type 2 diabetic complications.

Methodology: We did a 12-week Prospective follow-up for adult Ethiopians with Type 2 diabetes (mean age of 48.15±6.8yrs) assigned to supervise PRT at the University of Gondar Hospital, North West Ethiopia. Using convenience sampling, we select 22 DM patients. Of the 22 subjects recruited for experiment, 2 withdrew following the intervention. Glycemic control, CVD risk markers and body compositions were determined before and after the intervention. Weight, body composition, fasting blood glucose, low density lipoprotein (LDL) and total cholesterol, were used as the main outcome measures.

Results: Only 20 study subjects completed the 12-week PRT (three times per week) before (Baseline) and after the intervention the PRT reduced fasting blood glucose (FBG) (28.1%), T. cholesterol (12.9%), triglycerides (33.1%), resting pulse rate(9.9%), resting systolic blood pressure (11.4%), resting diastolic blood pressure (6.9%), weight (1.9 %), BMI (2.5%), body fat percentage (9.7%). There was an increase in muscle and bone density (1.5 %) $p < 0.05$; LDL decreased in 4 % (P=0.36), visceral fat percentage dropping 3.9 %, (P=0.07). These were not significant in statistical terms (P>0.5)

Conclusion: Supervised PRT for 12 weeks resulted in a significant improvement in glycemic and blood pressure control, Dis-lipidmia and body composition of Type 2 diabetes patients. There is now suggestive evidence supporting the use of moderate intensity PRT for improving glycemic control in DM in Ethiopia.

Introduction

The term diabetes mellitus (DM) describes a metabolic disorder of multiple etiologies characterized by chronic hyperglycemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both [1]. According to the World Health Organization (WHO) estimate, the global burden of diabetes has increased from 177 million people in the year 2000 to194 million in 2003 and further to 246 million people in 2007 [1]. In 2009 the International Diabetes Federation suggested that the number of adults with diabetes in the world would expand by 54%, from 284.6 million in 2010 to 438.4 million in 2030. The projected growth for sub-Saharan Africa is 98%, from 12.1 million in 2010 to 23.9 million in 2030 [2,3]. According to an extrapolated data the prevalence of DM in Ethiopia was 2.5 % in the year 2000 which is estimated to rise to 3.5 % by 2030 [4].

The use of exercise as a therapeutic modality is an old concept which did not start gaining acceptance until the 20th century. Today, exercise scientists are exploring the limits of the therapy as medicine. An exercise prescription, like any other prescription (drug), has type and dose, that is, a dosing frequency, duration of treatment, therapeutic goal and anticipated adverse effects [5].

The muscle is a major metabolic organ, especially in disposing oral intake carbohydrates. Decreased muscle mass can contribute to reduced glucose disposal observed in elderly people. Decreased muscle mass and muscle function can also cause a decrease in energy expenditure which in turn leads to obesity and insulin resistance [6,7].

In contrast to most hormones, concentrations of insulin in the blood decline during exercise in people without diabetes because less insulin is secreted from the pancreas. Given that skeletal muscle is quantitatively the most important tissue in the body for glucose uptake, especially during exercise, and given the fact that insulin is the primary stimulus for glucose up-take into resting cells, this decline in insulin secretion during exercise at first seems paradoxical. However, the insulin requirement for glucose up-take diminishes during exercise, because muscle contractions stimulate glucose up-take into the muscle even when insulin is absent [8].

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Endurance exercise may not be good enough because many sedentary older men and women with Type 2 diabetes are unable to spend many calories when they perform the activities due to their low fitness level. Besides, endurance exercises cannot be recommended since excessive pressure on the feet can lead to callus formation and foot ulceration. The other exercise approach is resistance training. This approach enjoys the benefit of preserving or even increasing muscle mass which has an important effect on energy balance in diabetics due to an increase in resting metabolic rate [6,9].

High urban growth rates, dietary habits, reduction in physical activity, and increasing obesity have become prevalent in Ethiopia. Studies did so far have gaps in terms of life style and anthropological perspectives which are needed to elucidate the causes, prevention, and control of diabetes, especially in Ethiopia, where health outcomes are highly dependent on cultural variables. To date, physical activities have not received much importance in the daily life of the urban population. Physical exercise is considered as a profession for athletes or ball game players, rather than an integral part of healthy living amongst the general public. Moreover, to the author's knowledge no study has been conducted to evaluate the effects of aerobic and resistance exercise training in the Ethiopian context. That the effect of PRT has been known in the developed world and Asia does not mean it is popular elsewhere. Therefore, it needs to be tested in the Ethiopian context because genetic variations, differences in lifestyle, environment, demographic characteristics, infrastructure, etc., mentioned above make a difference.

This study thus aims to determine the effect of supervised Progressive Resistance Training (PRT) on body composition, glycemic control, and cardio vascular disease (CVD) risk markers reduction to prevent and control Type 2 diabetic complications. So, these attempts will have a significant impact on public health policy by providing PRT interventions as preventive factors. In addition, the research attempts to investigate whether the effect of PRT explained in various studies around the world are equally relevant to our setting or not.

Materials and Methods

The study was conducted using a prospective follow-up intervention for 40-60 year old adult, male Ethiopians with Type 2 DM patients assigned to supervised PRT at the University of Gondar Hospital, north west Ethiopia. Using convenience sampling, we approached 30 patients; 22 of them agreed to participate in the intervention follow-up study and signed the consent form. Of the 22 subjects recruited, 2 withdrew following the intervention. All the 22 subjects were screened for underlying diabetic complications with exclusion criteria set for this investigation. That is, subjects who had peripheral neuropathy, coronary heart disease (evidence of ischemic heart disease by history or positive resting or exercise electrocardiogram) were excluded. Especially designed progressive resistance training was administered three times a week intermittently.

Study design

A twelve-week outpatient, prospective intervention follow-up study was conducted in the Diabetic Clinic and Fitness Center. Study subjects attended the clinic at baseline (Week 0), at midpoint (Week 6), and end of the intervention (Week 12) on three occasions. Fasting blood glucose (FBG) was checked every week. They were advised not to consume alcohol or participate in vigorous physical activities 12 hours prior to clinic visit after an overnight fast. One of the clinic visits occurred in the morning for taking blood sample (venous blood) for the measurement of FBG and Lipid profile using automatic analyzer 902 and commercial Roche kits. The other visits were in the afternoon during which height (baseline only), plus rate and blood pressure (BP), body composition (weight, BMI, body fat%, visceral fat % and muscle and bone density) were determined using aneroid and mercury BP apparatus and a sensitive body composition analyzer, respectively at baseline. In Week 12 an incremental treadmill exercise test to exhaustion was performed and muscle strength assessed by one-repetition maximums (1RM) to set training loads.

Intervention

Each supervised session which included a 10-minute warm-up (brisk walk around the exercise facility, stretching, warming-up using a treadmill and a stationary bicycle), followed by a 30-minute PRT including bench press, weight lifting, pull down, leg press, dumbbell seated shoulder, press, knee extension and sit-ups as well as a 5-minute cool down (walk around the exercise facility, flexibility and stretching exercises were performed. The training load was set using a percentage of 1RM (1-RM 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), which was assessed for each individual per exercise. The goal was to achieve between 75 and 80% of the current 1-RM. Intensity of exercise load: 50-60 % of one repetition maximum in the first week with gradual increases by 10% every week, up to 80%, of 1RM within 30- 50 minute's duration for the following weeks. During weeks 2-6 the intensity of the exercise training was low (60-70%) baseline 1RM, whereas the intensity during weeks 7-12 was 70-80% of baseline 1RM. Rest interval was light exercise walking; the time allotted for recuperation depended upon the individual's recovery (between sets of 3 to 4 minutes & between repetitions on each set per exercise of 15-30 seconds).The training load increased progressively once subjects could successfully perform 3 sets of 15 or more repetitions at that load [10].

In addition, subjects were advised to follow the dietary schedule recommended by their health providers.

They were told to take 50-70 % of carbohydrate (Ethiopian traditional diet made of teff, which strands second only to dark rye in its fiber content and high cereal products); 10 to20 % of fat and 10 to 15 % of protein throughout the study. Verbal report was taken during every training session. Throughout the study all subjects were allowed to continue with the drug medication as prescribed by their respective physicians. All experimental procedures were approved by the Human Ethics Committees of the Research and Publications Office (RPO) of the University of Gondar, and all subjects provided informed written consent.

Data collected in study period

Weight, body composition, repeated fasting blood glucose, low density lipoprotein (LDL), total cholesterol, body fat percentage, visceral fat percentage and muscle and bone density status were assessed.

Data analysis

Descriptive statistics was calculated for main study outcomes. The data were tested statistically at 0.05 levels of significance (with 95% confidence intervals). Differences between means were determined by using paired T-test techniques. Effects of the treatments on dependant variables and their interactions over time were analyzed. Statistical analyses were conducted using standard statistical software (SPSS version 15.0 for Windows) [11].

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Results

We studied 20 study subjects (mean age 48.15±6.8yrs) completed the 12 week training program. The results of the study indicated that the duration of diabetes seemed to have no influence on the blood lipid profile, cardiovascular status, and fasting blood glucose level in the selected diabetic subjects (Table 2).

Cardiovascular outcomes

There were significant reductions in both pulse rate, systolic and diastolic blood pressure (BP) of the mean value in all study subjects by (9.9 %, P=0.002), (11.4 %, p=0.001), (6.9 %, p=0.001), respectively at week12 (Table 1,2).

Fasting blood glucose level

There were significant reductions in fasting blood glucose level from the mean value of 184.9 ± 60 mg/dl baseline to 134.9 ±31.4 mg/dl (28.1 %, p<0.001) after the 12 week intervention.

Lipid profile

Data on Triglycerides and total cholesterol profile were checked after 12 weeks of intervention with 33.1 % & 12.9 % reduced from the base line, respectively. The mean value of Total Cholesterol which was 209.8 ±46.6 mg/dl decreased to 185.1 ±36.9 mg/dl and triglyceride which was 264 ±182.1 mg/dl decreased to 181 ±60.3 mg/dl significant (p=.002 and p= 0.002). Low density lipoprotein slightly decreased but with no significant difference from baseline 116 ± 35.9 mg/dl after treatments 110.92 mg/dl ± 28.7, P=0.219 (Table 1,2) (Figure 1).

Weight and body composition

The overall mean weight loss after intervention was 1.13 kg (P=0.003). There was an increase in muscle and bone density after 12 weeks of treatment intervention; the base-line mean value was 26 ± 1.7 after intervention 26.45 ± 1.78 (p=0.005). Increases in muscle bone density were inversely related to weight and body fat % (r= - 0.630, P=0.004 and - 0.910, P=0.000), respectively. Reductions in body fat percentage 9.7% (P=0.001), visceral fat 3.65 % P=0.001) and reductions in body weight were positively related to reductions in fasting blood glucose T. Cholesterol and triglyceride (P=0.03), (P=0.02), (P=0.04), respectively. Diabetic medication regimens were reduced for two individual with no additional change for the rest of the group (Figure 2).

Discussion

Twelve weeks of planned training increased muscular strength, controlled blood glucose level and dis-lipdimia significantly. These results on physical performance, body composition, and blood lipid profile parameters reflected the outcome of glycemic control parameters just in part. As could be expected, moderate intensity PRT resulted in a significant improvement through controlling the blood glucose level. Several studies have shown that the addition of exercise to diet provided significantly favourable effects on body composition rather than facilitating weight-loss. A similar study conducted in USA has shown progressive resistance training as an adjunct to standard of care is feasible and effective in improving glycemic control and some of the abnormalities associated with the metabolic syndrome among

No.	**Variable**	**Baseline mean**	**After treatment mean**	**Change Mean**
1	Fasting blood Glucose	187.6	134.94	28.1 %
2	T. cholesterol	212.47	185.13	12.9 %
3	Low density lipoprotein	115.57	110.92	4 %
4	Triglycerides	270.42	181	33.1 %
5	Resting pulse rate	83.3	75.15	9.9 %
6	Resting systolic blood pressure	140.25	124.25	11.4 %
7	Resting diastolic blood pressure	86.75	80.75	6.9 %
8	body weight	73.77	72.36	1.9 %
9	Body mass index	25.6	24.97	2.5 %
10	Body fat percentage	33.02	29.81	9.7 %
11	Visceral fat percentage	14.84	14.26	3.9 %
12	Body muscle and bone density	26.1	26.5	1.5 %

Table 1: Comparing percentage of mean change between baseline & after 12 weeks of treatment group.

Variable		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	FPG	52.6579	39.6587	9.0983	33.543	71.7728	5.788	18	.000
Pair 2	T. Colistrol	27.342	31.376	7.198	12.219	42.465	3.799	18	.001
Pair 3	LDL	4.658	21.859	5.015	-5.878	15.194	.929	18	.365
Pair 4	Triglyceride	89.421	147.220	33.775	18.463	160.379	2.648	18	.016
Pair 5	Resting P.R	8.150	10.624	2.376	3.178	13.122	3.431	19	.003
Pair 6	R. Systolic B.P.	16.000	16.190	3.620	8.423	23.577	4.420	19	.000
Pair 7	R. Diastolic B.P.	6.000	5.982	1.338	3.200	8.800	4.485	19	.000
Pair 8	BMI	.6232	.9129	.2094	.1831	1.0632	2.975	18	.008
Pair 9	Body Weight	1.4158	1.9366	.4443	.4824	2.3492	3.187	18	.005
Pair 10	Body Fat	1.3684	2.0028	.4595	.4031	2.3337	2.978	18	.008
Pair 11	Visceral Fat	.579	1.346	.309	-.070	1.228	1.874	18	.077
Pair 12	Bone Muscle Density	-.3526	.4993	.1145	-.5933	-.1120	-3.078	18	.006

Table 2: Statical correlation of Paired Sample Test between baseline & after treatment.

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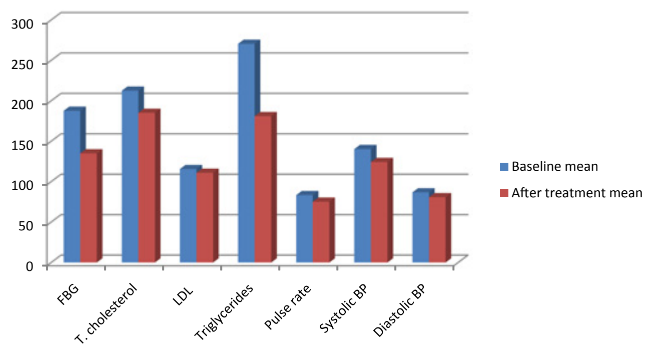

Figure 1: Pre and post test values of Lipid profile, Fasting blood glucose & cardiovascular states.

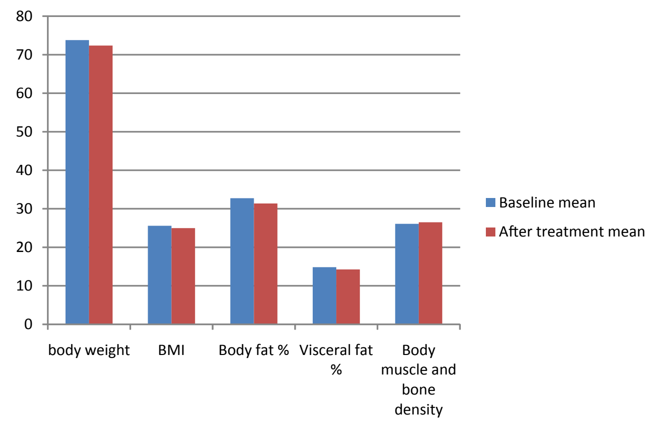

Figure 2: Pre and post test values of body composition states among diabetics treatment groups.

high-risk older adults with Type 2 diabetes [10]. Lean tissue loss that often occurs with energy-restriction is associated with reductions in resting metabolic rate acting to preserve fat stores and preventing further weight-loss. Changes in energy expenditure result from altered body weight [12]. Cholesterol reductions are associated with body weight, percentage of body fat, and dietary fat reductions. In this study, data on body composition, lipid profile (Total Cholesterol and TG) significantly improved after 12 weeks of treatment which had a significant correlation in decreasing fasting blood glucose level.

A study conducted by using lipid infusion in healthy subjects indicated that increased plasma-free fatty acids (FFA) reduce insulin-mediated glucose uptake. This finding confirms that incidence of obesity induced-insulin resistance is common in a Type 2 diabetes mellitus patients. Various metabolites of FFA, such as ceramide, have been suggested to decrease insulin sensitivity in skeletal muscle [12]. The resistance exercises are known to produce an increase in the lean body mass of the trainees and thus build a positive base for better insulin action in type two diabetics. Twelve weeks of strength training increased muscle and bone density. This will increase resting metabolic rate and improve postprandial blood glucose level.

Besides, this study found out that a significant reduction of T. cholesterol and Triglyceride which has a direct relation to decreases in body fat so as to improve the glucose up-take by the skeletal muscle has been observed to reduce resting blood glucose level (P= 0.000)after 12 weeks of intervention. A similar study conducted on an elderly DM patient showed that PRT offers a safe and effective exercise alternative for these people [11]. It promotes favorable energy balance and reduced visceral fat deposition through enhanced basal metabolism and activity levels while counteracting age and disease related muscle wasting. It also improves insulin sensitivity and glycemic control. In addition to increasing muscle mass, strength and endurance, it has positive effects on bone density, osteoarthritis symptoms, mobility impairment, self-efficacy, hypertension, and lipid profiles [13].

The effects of exercise on reducing blood pressure levels have been demonstrated most consistently in hyperinsulinemic subjects. Hypertension and diabetes are well-defined risk factors affecting the same target organ the heart. Clinically, hypertension and diabetes often occur together with approximately 80% of diabetics being hypertensive. In the present study, improvement has been observed in the blood pressure and resting heart rate showing the effects of the resistance exercise in preventing a chronic complication that comes as a result of hyperglycemia [14].

A similar study conducted on Asian Indians with Type 2 Diabetes showed that a moderate-intensity PRT for 3 months resulted in a significant improvement in insulin sensitivity, glycemia, lipids, and truncal and peripheral SCAT in patients with Type 2 DM, but no significant changes were noticed in BMI or levels of total body fat, truncal fat, and lean body mass [15]. However, in our study there were significant improvements in muscle and bone density as well as reductions in body fat percentage and visceral fat which were positively related to reductions in FBG total cholesterol level.

Therefore, compared to resistance exercises with drug alone, it may be true that a higher number of motor units are activated during exercise, and have health-related beneficial effects on skeletal muscles, such as improvements of the endothelial function and an increased enzyme capacity of energy metabolism. There are two specific effects of contracting skeletal muscle cells on the ability to transport glucose into these cells. First, a regularly performed training increases the content of the glucose transporter protein GLUT-4 within the cells. Secondly, a single bout of muscle contractions leads to a translocation of GLUT-4 to the sarcolemmal membrane which acutely enhances glucose transport capacity [16].

This study showed that substantial weight-loss and improvements in cardio-metabolic status and fasting blood glucose level occurred following 12 weeks of resistance training compared to the base-line test.

Similar to our findings, other Type 2 DM researchers in Asia who intervened with PRT regiment alone reported improvement in blood glucose and dis-lipidmia in sedentary non obese patients.

Conclusion

Supervised PRT for 12 weeks resulted in a significant improvement in glycemic and blood pressure control, weight reduction, lipid profile and body composition of Type 2 diabetes patients. It is therefore recommended that DM patients should make positive changes in their lifestyle by doing resistance exercise to counter the progressive ill effects of the disease. Although further studies on larger subjects are necessary to provide adequate advice to policy makers, we believe that our findings qualify us to recommend PRT for Type 2 DM patient care.

Limitation of the Study

We very well know HbA1c is the best test for assessing control, but we were not able to obtain the test during the study. So we ended up using reputed FBG test which turned out to be one of the limitations of the study. We decided to omit the controls as the data on them was not complete. During the study subject recruitment, only male patients who consented for the purpose were included. A strict control on change in diet and medication was impossible on patients who were at home leading normal life. So this could be considered as a limitation as well. As the machine we used had periodical internal and external quality confirmation, we believed it had no significant impact on our work. Like any other machine, however, it could have some undetected defects for which we had no control mechanism in place during the study period.

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