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Effect of Resistance Training on Preferred Walking Speed Performance and Fasting Blood Sugar Level in Subjects with Type 2 Diabetes Mellitus: A Randomized Controlled Trial

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ABSTRACT

Background: Diabetes mellitus is one of the most common metabolic diseases with devastating effects and leading cause of disability and often results many functional limitations in daily activities of life. Diabetes is a risk factor for lower muscular strength, walking speed and accelerated decline in functional status. Inclusion of exercise in life style management provide a better prevention of diabetes. Resisted exercises have a positive effect on improving muscular strength and walking speed and Fasting blood sugar level in subjects in type 2 diabetes mellitus.
Objective of the study: The primary objective of the study was to find the effect of resisted exercises on improving on preferred walking speed performance and Fasting blood sugar level in subjects with Type 2 Diabetes mellitus.
Method: Pre and post-test experimental study were conducted on 60 subjects, who were divided into two groups with 30 in each. Group A received resisted exercise with conventional exercise and diabetes education while Group B received conventional exercise alone with Diabetes education. Duration of treatment was 3 days/week for 6 weeks. Preferred walking speed was assessed using Self Selected Walking Velocity (SSWV) and fasting blood glucose were assessed by Fasting Blood Glucose Test (FBG).
Results & Conclusion: The results showed improvement on the gait speed and fasting blood sugar in both the groups. The improvement in Self Selected Walking Velocity in group A was significantly greater than group B ($p<0.05$). The study concluded that Resisted exercises is effective on improving gait speed and fasting blood sugar in subjects with T2DM.The term resistance training and resisted exercise training has used interchangeably in this article.

KEYWORDS: Resisted exercises; preferred walking speed; Fasting blood sugar level; type 2 diabetes mellitus

INTRODUCTION

A growing public health issue worldwide, Type 2 Diabetes (T2D) is particularly prevalent among adult Indians. Currently, 425 million persons worldwide live with diabetes, which affects 1 in 11 adults between the ages of 20 and 79.[1] Usual walking speeds are selected by majority people for their minimum energy expenditure and greatest walking efficiency. Walking speed is relatively slow due to limited aerobic capacity and additional demand for energy expenditure associated with physical activity.[2] Brain imaging studies have shown that reduced walking speed is associated with smaller hippocampal volume strength and cerebrocortical mass.[3] Diabetic participants walked 0.09 ± 0.15 m/s more slowly than those without diabetes, which reflects a clinically significant difference between groups.[4]

Andersen et al.[5] showed in an earlier study that DM2 is associated with loss of muscle strength around the ankle and knee joint. The loss of mobility and muscle. of the lower extremities can enhance each other. Inactivity will lead to loss of muscle mass, resulting in decreased muscle strength and vice versa increased muscle weakness will lead to an increased effort to be physical active. This will result in a negative spiral of become less active, losing muscle strength, loss of independence and health related quality of life.[6]

According to recent worldwide studies, walking speed is an important risk factor for fatigue, sarcopenia, osteoarthritis, disability, hospitalization, falls, premature death, cancer, depression, cognitive impairment, high blood pressure, and obesity and T2D in older adults.[7,8] Walking is the most ancestral form of physical activity in humans, easily applicable in daily life. It might serve as a first modest step toward enhancing lifestyles for many patients. However, the majority of diabetic patients do not participate in any weekly walking, exercise requirements. In older persons, gait speed predicts mobility, illness, and mortality.[9] Diabetes is associated with slowed stride and functional deterioration.[10] Physical inactivity is strongly linked to the occurrence of new-onset diabetes. [11,12,13]

Brain imaging studies have shown that reduced walking speed is associated with smaller hippocampal volume and cerebrocortical mass.[3] In older adults, gait characteristics have been linked to grey matter atrophy and white matter hyperintensities.[14,15] Moreover, grey matter atrophy appears to have a stronger effect on locomotor control in those with type 2 diabetes as compared those without, suggesting that the control of walking may be more dependent upon supraspinal control within this population.[16]

Gait characteristics varies in individuals with diabetes when compared with those who do not have diabetes mellitus. [17] Individuals with diabetes walk slower and with shorter step lengths, a longer stance phase, a wider base of support, greater step time variability on irregular surfaces, and inadequate pressure distribution at the foot when compared with subjects without diabetes mellitus. [18,19,20 21]

Individuals with diabetes have been demonstrated to have lower ankle mobility, ankle moment, and ankle power while walking than those without diabetes. Factors such as sensory impairment decreased lower-extremity strength, and central nervous system impairment are believed to contribute to this impaired gait. [18,19,20,22,23] Slow walking speed is linked to reduced executive function in both healthy adults and mild cognitive impairment (MCI). In MCI, slow walking speed is also linked to reduced cognitive processing speed.[24] A decrease in usual walking speed is a possible risk factor for conversion to MCI. [25] For these reasons, it is possible that intervention strategies that increase muscle strength and cognition are more efficient to improve walking speed than interventions that aim solely to increase muscle strength in Type 2 Diabetes mellitus.

METHODS

The study was conducted to fulfil the purpose of evaluating the effectiveness of resisted exercises on improving walking speed and fasting blood sugar level in patients with Type 2 Diabetes Mellitus. Before the study began, the sample size required for a statistical power of 80% was calculated based on the walking speed performances outcome from a previous study.[28]

Sixty subjects diagnosed with Type 2 Diabetes Mellitus of more than 5-year duration, both males and females of age between 45 to 69 years of age were recruited from Little Flower Hospital and Research Centre, Angamaly and private health care centres, Kerala. The study setting was the Physiotherapy rehabilitation centres and exercise therapy labs attached to recruiting centres. Eligible participants were categorised as per the pre-set inclusion criteria and exclusion criteria. The purpose of the study was well explained and a written consent was collected from all the participants. Only those willing to take treatment intervention for 12 weeks were included in the study The subjects were screened by using Diabetes Questionnaire, and PAR-Q Questionnaire for the preliminary data.

After this initial evaluation subjects were randomly assigned by lottery method into two groups consist of 30 participants each, Group A Resisted Exercise Group (REG) and Group B Control Group (CG) who receives no specific treatment. The concealed envelopes were used for lottery method. All the participants were blinded about the group assignments. The pretest and post-test values were assessed; initially the blood samples for biochemical variable were collected, followed by preferred walking speed assessment. Post-test values were collected on the last day of the 12-week intervention program. Preferred walking speed was assessed using self-selected walking speed test. A distance of 12 m was marked on the floor, with approximately 3 m on either side to allow for acceleration and deceleration. Participants are instructed to walk at a normal pace across the room, until they are told to stop. The time to walk the centre 6 m is recorded in seconds to 2 decimal places.

The resistance in the current study was given by free weights and body resistance. In rehabilitation, free weight and cuffed weights are often used. Hand-held weights are usually used in free weight exercise. Free-weight practice allows for more diverse resistance changes, and resistance can vary from one side to another side. The free-weight equipment is inexpensive, and the same free weights can be used for a variation of exercises. With free weights the exercise can be done at various speed and the working range of motion can be changed. Altering the position or range of motion can change the connection with gravity, which affects the performing muscle groups and type of contraction. Free weight exercises enable a multiple way of possibilities that matches the exercises with the individual's goals. [26]

Recent guidelines in the American Diabetic Association (ADA) supports the ACSM recommendations that resisted exercise training incorporated as effective strategy of a well prescribed bodily activity regime for individuals with T2DM, those haven't any barriers to physical activity. Sigal et al. suggests that resisted exercise training should include all the main muscular groups, thrice weekly, gradually progress to eight to ten repetitions at an external load that cannot be raised at least more than eight times. [27]

Resistance training protocol

The RT protocols follow the recommendations of the American College of Sports Medicine Guidelines for muscle hypertrophy and strength (American College of Sports, 2009). The total body RT protocol consisted of eight dynamic exercises for upper and lower limbs performed in a total-body routine with 8–12 repetitions per set at 70% of 1 RM and 1.5 min of recovery between sets and exercises.

In brief, a warm up session (one set of 15 repetitions) with 40% of 1 RM was done in each exercise before each RT session

The participants performed the resistance training for 45 minutes to one hour 3 days per week. The total body RT protocol consisted dynamic exercises for upper and lower limbs performed in a total-body routine. The resistance exercises given were biceps curls, triceps extensions, hamstring curls, Bridging Squats, quadriceps extension, calf raise or ankle raise, and abdominal curls as follows: Starting at an intensity of 40-50% of 1 Repetition Maximum progressed to an intensity of 60-70% of 1 RM and an intensity 75-80% of 1 RM respectively for 3sets of 8-10 repetition, with average speed, 30-sec resting phase amidst of sets. [29]

At the end of the RT sessions, there was a cool-down period with stretching exercises for full body which includes spine flexion, extension, and rotation, shoulder and elbow flexion and extension, hip and knee flexion and extension. The Control group did not participate in the RT routine; they are provided with only and stretching exercises twice a week, along with diabetic education which includes awareness on diabetic control, footcare, diet, role of exercise.

STATISTICAL ANALYSIS

Analyses were performed with SPSS version 20.0. Descriptive variables were reported in mean and standard deviation. Within group comparison of each variable were assessed using paired t test and for between group comparison was done using independent t test.

RESULTS

60 subjects who fulfilled the inclusion criteria were included in the study. The demographic characteristics of the subjects at baseline were normally distributed and are presented in Table1. When outcomes were compared at pre and post levels, significant improvements and statistically significant difference was proved in resisted exercise group for all the outcome measures. Subjects showed significant improvement in values of SSWV and FBS ($p<0.05$). When post values were compared between the groups, mean difference in resisted exercise group was more significant compared to control group ($p<0.05$).

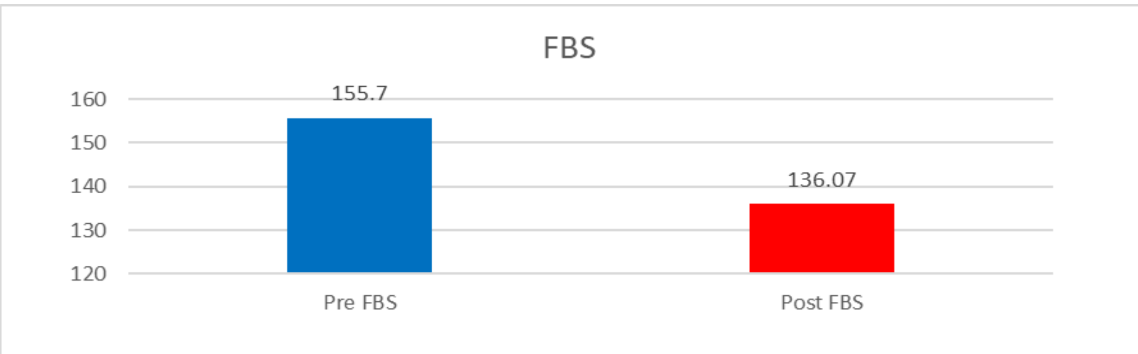
Table 1: Distribution of descriptive characteristics of the study groups

Variables		Resisted Exercise	Control group
		Mean ±SD	Mean ±SD
Age in years		60.03 ± 4.60	58.6 ± 5.02
Gender	M	60.0%	53.4%
	F	40.0%	46.6%
Duration		8.33 ± 1.71	8.67 ± 1.99

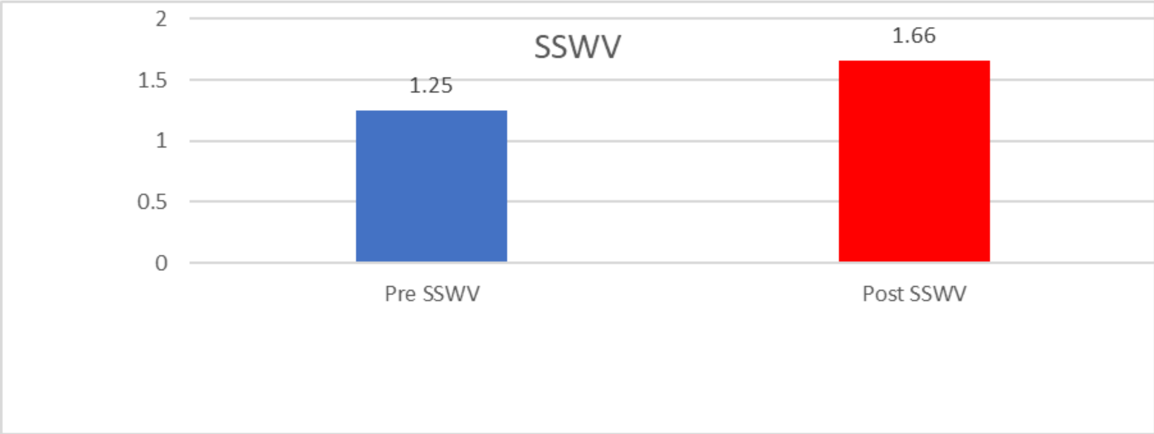
Table 2: Pre-test to post-test comparison of parameters in the resisted exercise group

	Mean. ± SD	t value	Sign
Pre FBS	155.70 ± 25.24	14.033	.000
Post FBS	136.07 ± 24.82		
Pre SSWV	1.25 ± 0.18	6.804	.000
Post SSWV	1.66 ± 0.42		

FBS – Fasting Blo od Sugar (mg/dL); SSWV - Self Selected Walking Velocity (m/s), p<0.05



Graph 1: pre and post mean scores of resisted exercise group



Graph 2: pre and post mean scores of resisted exercise group

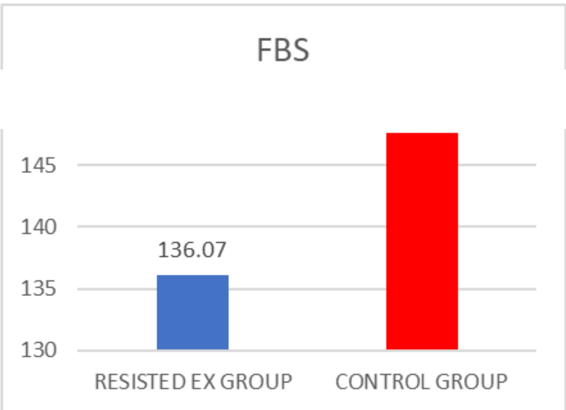
Table 3: Pre-test to post-test comparison of parameters in the control group

	Mean. ± SD	t value	Sign
Pre FBS	154.97 ± 22.53	4.244	.000
Post FBS	147.60 ± 18.77		
Pre SSWV	1.19 ± 0.12	1.665	.107
Post SSWV	1.21 ± 0.11		

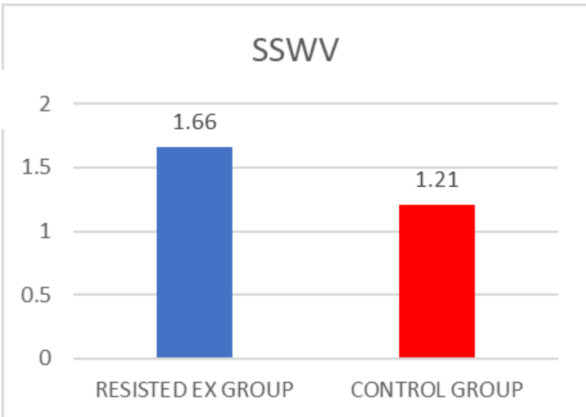
Table 4: Between group comparison of resisted exercise group and control group

	Dof	Mean difference	t value	Sign
FBS	58	11.53	2.030	.047
SSWV	58	4.44	4.784	.000

FBS – Fasting Blood Sugar (mg/dL) ; SSWV - Self Selected Walking Velocity (m/s), $p<0.05$



Graph 3: post mean scores of FBS among resisted exercise and control group



Graph 4: post mean scores of SSWV among resisted exercise and control group

DISCUSSION

To the best of our knowledge, this paper was the first interventional study to explore the effect of resistance training on self-selected walking speed performances and fasting blood sugar in subjects with Type 2 diabetes mellitus in Keralites. The main findings of our study were that the resistance training groups increase muscle strength as well as the self-selected walking speed performance and Fasting blood sugar after 12 weeks of intervention compared to control group. The results in the present study show that the baseline average self-selected walking velocity(m/s) of the resisted group 1.25 ± 0.18 m/s, which is in line with the findings of Kera T et al states that Individuals with diabetes walk slower

(1.3 m/s) than healthy adults (1.4 m/s).[30] The results estimated in the present study were still comparable and build on existing evidence of a study conducted by Santos et al; which shows the validity of our results. Santos et al states that the betterment in walking speed can be promoted by resistance training which may be linked with increased muscular strength.[31]

Walking Speed appears to be influenced by a number of factors. Fast Walking Speed may be influenced by age-induced alterations in body composition. Decreased voluntary muscular masses are linked with walking performance dysfunctions among type 2 diabetic patients. [32] Furthermore, an increase in body fat is linked to a decrease in gait. [33] The loss of muscular strength which are age- related is linked to poor functional capability and an advanced mortality rate in the older adults. [34,35]

Hortobagyi et al [36] conducted a meta-analysis that included twenty-four RCTs that assessed the impact of resistance training on walking capacity in older people. They found that resistance training improves walking ability by 9.3%. Increased lower limb muscular strength has been linked to a shorter duration to complete a speed test of walking in several cross-sectional studies.[37,38] It would seem reasonable to assume that increased muscular strength is linked to faster walking speed. It's possible that positive impact of resistance training on walking speed is linked to improvements in strength of the walking muscles mainly the gluteus, quadriceps, hamstring, and gastrocnemius.

In the study, Nunes et al found that high intensity resistance training at 70% of 1RM is effective in promoting improved fast walking speed performance.[39] Progressive Resistance Training with a rhythmical component, such as music, will improve gait speed and cognitive functions which are significant to gait. The most beneficial exercise approach for improving preferred gait speed is PRE at high intensities. Muscle strength appears to be a necessary condition for enhancing preferred gait speed. [40] In line with above mentioned studies related to resistance training the researcher turned to an assumption that increase in the muscle power, cognitive enhancement and neural adaptations which may be enhanced by resistance training could have been a reason for the significant improvement in walking speed among subjects with Type 2DM. In line with to the above-mentioned finding, it was stated that variations in torque production of isokinetic knee extension and flexion after 3months of progressive resistance training promotes development in executive functions. [41]

Another explanation for enhanced gait speed in the current study, even though the assessment of cognitive function was not a primary objective of this study, found that growth factors like IGF-1 may act as mediators for the influence of resisted exercise on the central level, resulting in an increase in cognitive functional capacity. In a study on aged people, Cassilhas et al discovered a substantial increase in IGF-1 serum concentration and enhanced cognition among the resistance exercise group as compared to the controls; the serum level has been linked to cognitive function.[42] The evaluation of gait speed is considered as predictor of late-stage cognitive decline. The research findings support the ongoing exploration and use of gait as a physiological biomarker of overall cognitive function and warrants longitudinal investigation in this high-risk group.

The gray matter atrophy appears to have a stronger effect on locomotor control in those with type 2 diabetes as compared those without, suggesting that the control of walking may be more dependent upon supraspinal control within this population.[43] Resistance training slow down white matter atrophy and accelerates grey matter volumes in different brain areas. Researches have proved that; resistance training depreciates white matter atrophy and escalate grey matter volumes in distinct brain areas. In regard with the observed association between structural changes and behaviour, the active role of resistance exercise training

in promoting and improving brain health is activated, and this in turn enhances the gait speed in diabetic population. Resistance training helps to increase type 2 muscle fibers. Type IIx fibers are found abundantly in individuals with T2DM. These fibers were found have no effect on the glucose disposal rate in patients. Resistance training helps for shifting type II x fibers to Type II a fibers. Type II a fibers were found to have a greater density of capillaries and insulin response than Type II x fibers. Resistance training helps to increase motor unit firing and decreased co contraction of antagonist muscles. Resistance training helps to improve muscle strength and increased motor unit firing.
Glycemic control is directly related with enhanced cardiovascular morbidity and mortality in Type 2 Diabetes mellitus, with researches showing a 1.18 rise in risk of cardiovascular pathologies. Studies have reported that resistance exercise training may modulates glucose metabolism and enhances pancreatic beta-cell function and insulin secretion, which may be associated with some factor released into the bloodstream in response to this type of exercise.[44] This is assumed as one of the possible reasons for the changes we found in the results of the study.

CONCLUSION

Effectiveness of an exercise lies on an effective exercise prescription and depends on the duration and intensity of the physical activity or exercise. Resisted exercise with proper exercise prescription and guidance can be advocated to improve physical performance, and biochemical functions according to the individual needs. The study findings will help the rehabilitation specialists to recommend the exercise intervention as per the individual need of the patients. These interventions can provide promising positive effects for an individual's physical and mental well-being, thereby helping to enhance physical and mental wellbeing. Hence the study results concluded that resisted exercise training is a promising intervention.

Declaration by Authors

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