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Comparative Effect Of Standard Balance Exercises And Progressive Resistance Strength Training On Balance In Patients With Diabetic Neuropathy.

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ABSTRACT

Introduction- Diabetic nerve dysfunction is a common adverse effect associated with type 2 diabetes mellitus (T2DM) that affects postural instability leading to a higher risk of falling. Balance impairment in diabetic neuropathy patients involves interventions to improve postural control. This research aims to determine the effectiveness of standard balance exercises and progressive resistance training in enhancing balance in in diabetic neuropathy patients.

Methodology- This interventional study used simple random sampling method to allocate participants into two intervention groups. A total of 48 participants (Group A =24; Group B=24) meeting the inclusion criteria of all genders aged 50-65 years with berg balance score of 20-44 and type 2 diabetes mellitus duration of 5-10 years, will be recruited. Group A received standard balance exercises and group B underwent progressive strength training following the Delorme and Watkins protocol. Both interventions conducted four sessions per week for a duration of four weeks. Baseline and post interventions assessments had taken using the balance measures such as the Berg Balance Scale and Timed Up and Go test.

Results- According to this study, both therapies showed marked enhancement in postural stability, demonstrated by reduced TUG durations and elevated BBS values. (Group A) BBS increased from 36.04 to 39.79 ($p < 0.0001$) and TUG decreased from 22.92 to 20.29 ($p < 0.0001$). (Group B) BBS improved from 36.50 to 40.58 ($p < 0.0001$) and TUG from 23.04 to 20.42 ($p < 0.0001$). Although Group B showed slightly better outcomes.

Conclusion- Patients with diabetic neuropathy can improve their balance with both resistance and balance exercises. Although there may be a little more benefit from progressive resistance training, both strategies are beneficial and may be customized for each patient's needs

Keywords*: Diabetic neuropathy, Balance exercises, Progressive resistance strength training, Berg balance score, Timed Up and Go mobility test.*

1. INTRODUCTION

Type 2 diabetes mellitus (T2DM), a widely occurring metabolic disorder, arises due to two primary causes: the reduced capacity of pancreatic β-cells to release insulin and the failure of body tissues to respond appropriately to it. The WHO reported that in 2019, 74% of worldwide fatalities were attributed to non-communicable diseases. Within this category, diabetes alone led to 1.6 million deaths, positioning it as the tenth leading global cause of mortality. By 2035, an estimated 592 million people are anticipated to have diabetes.[2] Physical activity delays the onset of type 2 diabetes in three main ways. First, the skeletal muscle cells contract, increasing blood flow to the muscle and improving the absorption of glucose from plasma. [1] Among the various complications of diabetes, injury to the peripheral and autonomic nervous systems frequently underlies a range of clinical manifestations.[3]

Diabetic neuropathy represents a frequent complication of Type 2 diabetes mellitus, impacting an individual's well-being. Among the complications of type 2 diabetes, diabetic peripheral neuropathy is most frequently observed, leading to high blood glucose, excessive urination, muscular debility, paraesthesia, and tingling in the hands and feet. DPN results in

neuromuscular system dysfunction, fatigue, and a decrease in exercise tolerance.[4] Patients with diabetes will experience balance issues as a result of peripheral nerve degeneration. Diabetic neuropathy contributes to various physical difficulties, including frequent falls and compromised equilibrium and motor coordination during ambulation or standing. Impaired gait is one of the problems that arises in the latter stages of DPN. Patient's quality of life is diminished by experiencing falls. [5]

Progressive diabetic neuropathy is characterized by the shrinking and regression of peripheral terminal sensory axons, though the perikarya (neuron cell bodies) typically remain unharmed. Given its characteristic "stocking and glove" distribution, diabetic neuropathy is categorized as a length – dependent neuropathy. This pattern shows that the longest sensory axons are affected initially (epidermal axon loss in the distal leg occurring before that in more proximal extremities). [3] Patients with DN primarily have medial lateral plane balance impairment, which is most noticeable when descending stairs. Patients with diabetes who exhibit changes in their gait should

be treated with consideration for both physiological (strength and proprioception) and cognitive behavioral (fear of falling) considerations. [7]

Balance exercises, which include static, dynamic, and functional approaches to patient treatment, are well-established sensorimotor training methods. Improvements in balance measurements in older persons with DPN have been documented following balance training. [8]

Progressive resistance training's positive effects on older people' muscle strength and bone mineral density, along with supplementary advantages such greater muscle mass, enhanced functional ability, and a lower incidence of falls and fractures.[9] Several factors predict or contribute to an individual's poor postural control during active movements, including the force production capacity of ankle muscles, insufficient strength in the hip flexor, extensor, and abductor muscle groups, and diminished torque and power from the knee flexors, extensors , ankle dorsiflexors, and plantar flexors.

Progressive Resistance Training (PRT) is an exercise methodology involving the gradual increment of resistance or load as an individual's muscular strength adavances, ensuring continuous challenge to the muscles.

Indications of PRT:

Increase your endurance and muscle strength.

Immediately following musculoskeletal operations or injuries, recover

Control nervous system disorders (such as stroke, Parkinson's, and diabetic neuropathy).

For osteoporosis and osteopenia, increase bone density

Control diabetics' blood sugar levels

Help elderly or deconditioned patients become more functionally independent.

Support weight management

People with type 2 diabetes have been demonstrated to benefit from PRT in terms of increased strength and motor function. The effects of PRT on individuals with type 2 diabetes and DPN, when compared to those without DPN and healthy control participants, have not yet been investigated using a randomized trail design. [11]

2. METHODOLOGY

A Comparative clinical, Interventional study conducted on patients with diabetic neuropathy at D.Y. Patil Medical College , Hospital & Research Institution, Kadamwadi, Kolhapur using Simple random sampling method with a sample size of 48, for a duration of 1 year.

Materials Consent form, Data collection sheet, Berg Balance Scale (BBS), Timed Up and Go test sheet (TUG), Chair, Stopwatch, Plinth, Foam board, Swiss-ball.

Study subjects fulfilling inclusion & exclusion criteria were selected for study.

Inclusion Criteria: Both male and female, Age group between 50 to 65 years, Berg balance score 20 to 44, Type 2 diabetes mellitus duration since 5 to 10 years, Ability to understand and follow the commands.

Exclusion Criteria: Cardiovascular diseases like myocardial infarction, coronary artery disease, arrhythmias etc., Unstable proliferative retinopathy, Uncontrolled hypertension, Osteoarthritis.

3. PROCEDURE

The study protocol was presented for approval in front of institutional ethical committee and college research protocol committee of D. Y. Patil Education Society Institution Deemed to be University, Kolhapur and D.Y. Patil College of Physiotherapy, Kolhapur. Participants were informed about the study aim. Only individuals who provided written informed consent were included in the study. The subjects selected according to inclusion and exclusion criteria.

There are 2 groups made, group A Experimental group and group B, PRT group. Equal number of samples divided into 2 groups randomly. From the overall 48 participants, 24 were allocated to group A and 24 to Group B. Over 4 - week period, participants in Group A received standard balance training and those in Group B undertook progressive resistance training.

Exercises for both groups were administered four times weekly during this timeframe. To assess outcomes, the Berg Balance scale (for balance assessment) and the Timed Up and Go (TUG) test were administered at two points : prior to the intervention and again after the fourth week of the intervention . Data recorded on data collection sheet and statistical analysis was done.

Group A – Standard Balance Exercises

EXERCISES	1st Week	2nd Week	3rd Week	4th Week
Weight shifts	5 repetitions× 3 sets	10 repetitions× 3 sets	15 repetitions× 3 sets	20 repetitions ×3 sets
Standing on one leg	5 repetitions ×3 sets	10 repetitions ×3 sets	15 repetitions× 3 sets	20 repetitions× 3 sets
Tandem walking	5 repetitions ×3 sets	10 repetitions ×3 sets	15 repetitions ×3 sets	20 repetitions× 3 sets
Cross over walking	5 repetitions× 3 sets	10 repetitions× 3 sets	15 repetitions ×3 sets	20 repetitions ×3 sets
Figure of eight walking	5 repetitions ×3 sets	10 repetitions× 3 sets	15 repetitions× 3 sets	20 repetitions× 3 sets
Forward, backward, sideways walking on foam (3–4-inch thickness with the length of 6.5 feet and width of 3 feet)	5 repetitions ×3 sets	10 repetitions× 3 sets	15 repetitions× 3 sets	20 repetitions ×3 sets
Perturbations of balance in all directions while sitting on plinth	5 repetitions× 3 sets	10 repetitions× 3 sets	15 repetitions ×3 sets	20 repetitions× 3 sets
Sitting balance on medium size Swiss ball	5 repetitions× 3 sets	10 repetitions× 3 sets	15 repetitions× 3 sets	20 repetitions× 3 sets

Group – B Progressive resisted exercises (Each week 1RM is progressed)

First week	Repetitions
Supine straight leg raise	10times with ½ of 1RM 10times with ¾ of 1RM 10times with 1RM
Prone straight leg raise	10times with ½ of 1RM 10times with ¾ of 1RM 10times with 1RM
Side lying leg raise	10times with ½ of 1RM 10times with ¾ of 1RM 10times with 1RM
Forward lunges	10times with ½ of 1RM 10times with ¾ of 1RM 10times with 1RM
Ankle dorsiflexion	10times with ½ of 1RM 10times with ¾ of 1RM 10times with 1RM
Ankle plantar flexion	10times with ½ of 1RM 10times with ¾ of 1RM 10times with 1RM
Abdominal crunches	10times with ½ of 1RM 10times with ¾ of 1RM 10times with 1RM

RESULT

TABLE 1: MEAN OF AGES OF BOTH GROUPS

Group	Mean	S.D.
Group A	60.71	3.06
Group B	61.50	2.25

The average age was determined for both Group A and Group B. Group A had a mean age of 60.71 (SD- 3.06), while group B the mean was 61.5 (SD-2.25).

TABLE 2: Pre-POST COMPARISON IN GROUP A (PAIRED-T TEST USED)

Group A -Standard balance exercises				
Variable	**Time Point**	**Mean**	**S.D.**	**P-Value**
Berg Balance Scale	Pre	36.04	4.03	1.25E-21*
	Post	39.79	4.05	
Time Up and Go Test	Pre	22.92	4.24	7.40E-19*
	Post	20.29	4.19	

The **Table 2,** presents a comparison of the Berg Balance Scale (BBS) and Timed Up and Go Test (TUGT) scores for Group A, detailing their performance before and after the intervention involving standard balance exercises.

The mean BBS score improved from 36.04(SD= 4.03) to 39.79(SD=4.05), with a significant p-value of 1.25E-21.

The mean TUGT Score improved from 22.92(SD-4.24) to 20.29(SD= 4.19), with a significant p- value of 7.40E-19.

Indicates P value (<0.0001) is significant

Both results indicate significant changes in Balance**.**

Table 3: PRE-POST COMPARISON IN GROUP B (PAIRED-T TEST USED)

Group B Progressive resistance strength training				
Variable	**Time Point**	**Mean**	**S.D.**	**P-Value**
Berg Balance Scale	Pre	36.50	3.67	5.35E-23*
	Post	40.58	3.82	
Time Up and Go Test	Pre	23.04	4.07	3.60E-12*
	Post	20.42	4.57	

(*indicates P-value (<0.0001) is significant)

The **Table 3,** presents a comparison of pre and post intervention scores on the Berg Balance scale and the Time Up and Go test for Group B, which used progressive resisted exercises. The mean BBS score improved from 36.50 (SD= 3.02) to 40.58 (SD=3.21), with a significant p-value of 5.35E-23.

The mean TUGT Score improved from 23.04 (SD- 4.07) to 20.42 (SD= 4.57), with a significant p- value of 3.60E-12.

Indicates P value (<0.0001) is significant

Both results indicate significant changes in Balance

Table 4: GROUP-WISE COMPARISON (BY USING UNPAIRED T-TEST)

Variable	**Group**	**Mean**	**S.D.**	**P- Value**
Berg Balance Scale	A (Standard balance exercises)	39.79	4.05	0.2449*
	B (Progressive resistance strength training)	40.58	3.82	
Time Up and Go Test	A (Standard balance exercises)	20.29	4.19	0.4608*
	B (Progressive resistance strength training)	20.42	4.57	

(*indicates P-value (<0.05 is significant)

The **table 4,** presents group wise comparison on the Berg Balance scale and the Time Up and Go test .

The mean BBS score for group A 39.79 (SD= 4.05) compared to group B 40.58 (SD=3.82), with significant p-value of 0.2449.

The mean TUGT Score for group A 20.29 (SD=4.19) compared to group B 20.42(SD= 4.57), with a significant p- value of 0.4608.

Indicates P- value <0.05 is significant

Both results indicate significant changes in Balance.

4. DISCUSSION

Group A demonstrated improvement in the TUGT and BBS that were statistically significant. The mean BBS score before the intervention was 36.04 ± 4.03, and after the intervention, it was 39.79 ± 4.05. 20.29 ± 4.19 seconds was the improvement in the TUGT time from 22.92 ± 4.24 seconds. The BBS scores of Group B also improved, rising from 36.50 ± 3.67 to 40.58 ± 3.82, and the TUGT time decreased from 23.04 ± 4.07 to 20.42 ± 4.57 seconds which shows improvement. Both interventions were effective, as evidenced by the highly significant p-values ($p < 0.0001$) for both outcome measures in each group.

The comparison of post-intervention ratings between the two groups revealed slight statistically significant difference, despite the fact that both groups exhibited significant improvement from baseline (BBS p=0.2449; TUGT p=0.4608). The fact that Group B's mean improvement was higher, however, is significant and suggests that PRT may have an advantage.

Balance training has been shown in earlier research to improve postural control by improving vestibular input and proprioception, both of which are frequently impaired in DN. The foundation of support is tested and sensorimotor pathways are activated by the static and dynamic motions of standard balancing exercises (as employed in Group A). Exercises focused on balance lead to neuromuscular re-education, improved postural alignment, and decreased risk of falls. [8]

However, it has been demonstrated that progressive resistance strength training (PRT) improves strength of the muscle, endurance & neuromuscular coordination. For individuals suffering from type 2 Diabetes and diabetic neuropathy, PRT leads to better functional outcomes, especially when targeting the major muscle groups of the lower limbs. PRT improves the activation of motor units, promotes muscle growth, and may even promote neuromuscular junction regeneration alterations. [10,11,] Moreover, PRT enhances joint stability and dynamic balance, which indirectly influences postural control in addition to increasing muscle strength. By enhancing muscular activation patterns during weight-shifting and locomotion, resistance training can mitigate the distal muscle weakening and proprioceptive loss associated with DN. [7,13]

A complex integration of visual, vestibular, and somatosensory inputs maintains balance and postural control. The somatosensory component of DN is frequently compromised, particularly in vibration and location sense. While PRT handles the musculoskeletal and neuromotor aspects, standard balance training focuses on retraining sensory integration and adaptive responses. The efficiency of each strategy may therefore be explained by the fact that they each address distinct physiological deficiencies. According to earlier research, Group B's marginally better results may have been caused by increased ankle and hip joint torque. PRT may also result in changes to the central nervous system, which would enhance postural reflexes and force development rate improvements. These neuroplastic effects are especially advantageous for chronically ill older persons.

For patients with diabetic neuropathy, both resistance and balance exercise should be regarded as crucial elements of their rehabilitation. Based on the unique characteristics of each patient, therapists may select one of these modalities; for example, balance exercises may be better suited for frail or cognitively impaired patients, whereas PRST may be more appropriate for those with retained musculoskeletal and cognitive abilities. The best results might come from an integrated strategy that combines the two kinds of interventions. [13] This study concludes by highlighting the similar efficacy of progressive resistance strength training and standard balance exercises, as well as the relevance of physiotherapy in controlling balance impairments in DN. Future studies should assess changes in fall incidence, quality of life, and brain plasticity as well as investigate the long-term consequences of combined procedures.

5. CONCLUSION

Both Progressive Resistance Strength Training and Standard Balance Exercises considerably enhance balance in diabetic neuropathy patients, according to the study's findings. Although the two groups' BBS and TUGT scores improved somewhat more with Progressive Resistance Strength Training, the difference was slightly statistically significant. Therefore, both approaches can be successfully included in diabetic neuropathy physiotherapy rehabilitation programs to improve functional independence and lower the risk of falls.

It is advised to use a customized strategy depending on the requirements, skills, and comorbidities of each patient. To confirm the superiority of one intervention over the other or to confirm the possible advantages of combining both training methods, more research is required with bigger sample numbers and longer intervention durations

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