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ORIGINAL ARTICLE

EFFECTS OF MULTISENSORY EXERCISES ON IMPROVING PHYSICAL FUNCTION AND REDUCING NUMBER OF FALLS IN SUBJECTS WITH DIABETIC NEUROPATHY

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ABSTRACT

Background: Impaired sensations associated with PN in type 2 Diabetes, are thought to cause balance impairments that can increase the incidence of no: of falls and progressive deterioration of physical function. MS Exercises that have proved to improve balance are thought to be more effective in improving physical function and reducing no of falls. Objectives of the study was to determine the effect of MS Exercises in improving physical function and in reducing no: of falls. **Methods:** Thirty patients diagnosed as type 2 DPN were enrolled, and subdivided into experimental group (n=15) and control group (n=15).The experimental group practiced MS balance exercises and Control group practiced balance exercises for 30 minutes, thrice a week, over 6 weeks. Outcome measures used were Lower Extremity Functional Scale (LEFS) to assess physical function and 'Timed Up and Go' (TUG) test for assessing no: falls. The statistical methods used were Wilcoxen Signed Rank Test and Mann whiteny U Test. **Result:** Based on the statistical analysis, the result showed that there was statistically significant difference in improving physical function and reducing no: of falls between pre-test and post-test values of both groups. Experimental group showed greater improvement in physical function while measuring with LEFS and reduction in no: of falls while measuring with TUGT than control group in subjects with Type 2 DN. **Conclusion:** The clinical observation suggests that the MS Exercises is an effective intervention in improving physical function and reducing no: of falls in subjects with type 2 DN.

Keywords: Diabetes, Diabetic Neuropathy, Multisensory exercise, Physical function

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INTRODUCTION

Diabetes is a complex metabolic disease that results in impaired metabolism of carbohydrates, fats, and proteins[1]. Long term effects of DM can cause progressive development of the specific complications of neuropathy, retinopathy, nephropathy and autonomic dysfunctions. Along vascular and neuropathic co morbidities, the threats of physical disability, loss of independence, and diminished quality of life may ultimately be the greatest concern for many with the disease[2,3,4,5].

Type2 DM and its most common complication, PN, affect a large population. An internationally agreed simple definition of DPN for clinical practice is "the presence of symptoms and/or signs of peripheral nerve dysfunction in people with diabetes after the exclusion of other causes" [6]. In India, the prevalence has ranged from ranges from 21%-31% [11,7]. Age, poor glycemic control, increasing duration of diabetes, gender, height, body mass index, and retinopathy, hypertension, smoking, and alcohol consumption are the risk factors for DPN[8,9,10,11].

Peripheral neuropathy affects the sensory, motor, and autonomic components of the peripheral nerves especially in lower limb[12]. Clinically, DPN presents sensory and sometimes motor function abnormalities in the lower legs and the hands. Sensory abnormalities in the lower leg present earlier than motor abnormalities during disease progression. Hands are usually involved only in more severe cases of DPN.

Symptoms of DPN are often stocking-like in Nature and may include burning or aching pain in about 50% of individuals along with paresthesia, numbness, cramping, nighttime falls; however, others may report painless, numb feet. The muscular symptoms include muscle weakness, atrophy, balance problems, ataxic gait. Clinical signs of DPN include bilateral lower extremity loss of touch, pressure, vibratory, position, and temperature sensory perception and decreased ankle reflexes. Signs and symptoms depend on whether large and/or small nerve fibers are affected. Diabetes can increase accidents through poor balance issues due to numbness in the toes and feet[13,14].

Diabetic neuropathy plays a significant role in falling among elderly patients since they often experience balance disorders induced by long standing diabetes[15,16]. Balance is controlled on the basis of afferent information from somatosensory input, visual and vestibular system. The first two systems are often affected in presence of diabetic neuropathy[17]. Long lasting hyperglycemia that causes impaired proprioception and extroception induces disturbed body balance and locomotor activities which triggers injurious accidents[18].

Postural control mechanisms is based on postural sway information detected from visual, vestibular and peripheral receptors[19]. Due to the lack of accurate proprioceptive feedback from the lower limbs, Persons with PN show postural instability with a larger centre of pressure displacement, higher sway area and greater instability especially when standing still with eyes closed[20].

Diabetic persons with PN have lower gait velocity, decreased cadence, shorter stride length, increased stance time and higher step to step variability compared with healthy controls. These gait alterations increase on irregular surfaces. Also lower limb strength,

fear of falling and sensory problems to be related to spatiotemporal gait alterations [17].Patients with DN have a fivefold increased risk of falling[21,22,23].

In the lower extremities, impairments can cause instability while walking or standing and lead to falls and functional limitations[24]. Limitations in physical functioning can lead to a loss of independence because activities like walking are critical for the maintenance of independence in a community[24, 25].

In DPN, Exercise therapy, including balancing exercises, leads to increased oxygen pressure in lower limbs, skin, and chest of diabetic patients, improving blood flow[26]. Any changes in shear stress and pressure on the soles of the feet during standing tasks can stimulate mechanoreceptors to the higher nervous centers, which leads to increased balance ability in patients with DN[27].

MS stimulation approach is a therapeutic program that uses sensory stimulation that helps sensory-impaired patients to recover functional sensibility in the affected area and learn adaptive functioning. It helps patients with sensory loss and impairment to retrain their sensory pathways, adapt to changed capacities, and regain function[28].

The lower extremity functional scale (LEFS) has high level of validity and reliability to all levels of function[29].

The 'Timed Up and Go' test (TUG-test) is an very effective method for assessing mobility and quantifying locomotor performance, including a sequence of functional maneuvers that is used in everyday life[30].

Background of the Study: Impaired sensations associated with DPN in type 2 Diabetes, due to peripheral nerve damage, are thought to cause balance impairments. Later on, there will be increase in no: of falls and progressive deterioration of physical function. Symptoms are troublesome that they create anxiety and depression, interfere with work, ADL, failure in meeting family and social responsibilities, attaining adequate rest and sleep, and hindering patients to see their medical providers. Various interventions have been practiced by physical therapist to improve balance. Many studies have proved that diabetic neuropathy patients benefits from sensory training to improve balance. MS exercises that are meant to improve balance are thought to be more effective in improving physical function and reducing no of falls.

Purpose of study: To find the effect of MS exercises in improving physical function and reducing number of falls in patients with DN.

METHODOLOGY

Study design: Pre versus post test experimental design.

Study settings: Outpatient department of Bethany Navajeevan College of physiotherapy, Trivandrum; Physiotherapy settings in hospitals and clinics in and around Trivandrum; Old age homes in and around Trivandrum.

Sample size: 30 samples of the population who satisfied the inclusion and exclusion criteria were selected.

Inclusion criteria

- Age between 55 to 75 years both gender.
- Diagnosed as Type 2 DPN by physician.
- Patients complained of burning pain with paresthesia in both legs.

- Strength of lower extremities were not less than grade 3
- Patient having both sensory and balance impairment.
- Ability to walk 6 minutes continuously and unassisted.
- NDS 3 to 8
- Without medical contraindication for engaging in physical activity.
- History of fall more than once.

During the study period, both groups continued to receive the usual recommended medical care, which included pharmacological treatment and self-care instructions. The use of analgesics was allowed, but had to be unchanged for at least four weeks before entering the study and during the study.

Exclusion criteria

- Concomitant foot ulcer at the moment of intake.
- Orthopedics or surgical problems affecting gait variables.
- Non DN and other neurological pathologies other than PN that could influence gait variables
- Uncontrolled cardiovascular, respiratory, visual impairment without correction
- Cardiac arrhythmias, cardiac pacemakers, infections and ankle deformities or injuries.
- Those who were involved in regular physical training during the previous 3 months were excluded

Study duration: The study was conducted over a period of nine months.

Objectives of the study: To determine the improvement in physical function and to determine reduction in no: of falls.

Outcome measure:

- Lower Extremity Functional Scale (LEFS) for measuring physical function.
- Timed Up and Go Test (TUGT) for measuring no: of falls.

Procedure: A Total of 30 patients were recruited, using purposive sampling, fulfilling inclusion and exclusion criteria. Prior to testing all eligible participants were verbally instructed as to the intent and protocol of the study. Nature and possible risks of the experimental procedures were explained and signed informed consent was collected. Demographic details of each subject were taken. Total of 30 patients were divided into two groups. 15 subjects will be allocated in experimental group and 15 subjects will be allocated in control group. All outcome measures were assessed at baseline and after 6 weeks. The therapist stood beside the participant to guarantee physical safety in case of loss of balance. The intervention group and control group were allowed to continue their usual leisure activities. Participants were instructed to report any symptom or feeling of falling during the exercise session.

Experiment group[38] received multisensory balance exercises interventions for 30 minutes, 3 sessions each week for 6 weeks.

Warm up(5 min)- Short walks, games with balls using hand and feet.
Walking forward, backward, sideways- With eyes opened and eye closed, At different speeds and various distances By varying ground surface, Regular floor (5min), Mattress (5min), Foam rubber (5min).
Challenges from obstacles- Ropes, Sticks, Cones.

Bipedal support- unipedal stance, Eye open, firm surface, Eye open, soft surface, Eye closed, firm surface, Eye closed, soft surface.

Double legged stance(10s),Tandem stance(10s), aising from chair without using arm, Walking forward, backward with a tandem walking pattern(toe of one foot touching the heel of the foot on front Single legged stance(10 s), Last session lasted for 10 mins.

Control group[39] received balance for 30 minutes, 3 sessions each week for 6 weeks.

warm-up(5min)- Short walks and games with balls, using hands or feet. Walk forwards, backwards, and sideways.
Performing double-legged stance (10 sec hold, 10 reps), Performing tandem stance (10 sec hold, 10 reps), Performing single legged stance (10 sec, 10 reps), Raising heels in the standing Position (1 min), Raising toes in the standing position (1 min), Weight shifting Exercise (1min), Maintaining balance on both feet will perform small knee bends to change balance (1min).

Statistical Methods: Using Microsoft Excel, data was converted into SPSS (Statistical Package for Social Sciences) format for analysis. SPSS version 16 was used. The pretest and post test values of both group was compared using Wilcoxen Signed Rank test. Post test values of both group (group A and group B) were compared and statically analysed using MannWhiteny U test.

RESULT

Comparison of Pre Test Vs Post Test scores of LEFS and TUGT in Experimental Group

Descriptive Statistics

Group A		N	Mean	Standard Deviation	Mean Difference	Z Value	P Value
LEFS	Pretest	15	48.23	2.421	7.46	-3.193	.001
	Posttest	15	55.69	5.154			
TUG	Pretest	15	13.9615	.57379	3.4077	-3.184	.001
	Posttest	15	10.5538	1.49979			

Table 1: Comparison of pretest and post test values of LEFS and TUGT of experimental group (Group A).

Comparison of Pre Test Vs Post Test scores of LEFS and TUG in Control Group

Group B	N	Mean	Standard Deviation	Mean Difference	Z Value	P Value
LEFS	15	48.67	1.799	0.114	-3.424	.001
	15	51.87	1.685			
TUG	15	13.7733	.48766	1.52	-3.413	.001
	15	12.2533	12.2533			

Table 2: Comparison between pre and post test scores of LEFS and TUGT in control group (GroupB).

Comparison between Post Test scores of LEFS and TUG in Experimental Group Vs Control Group

Outcome Measure	Group	N	Sum of Ranks	Mann Whitney U Test	P Value
LEFS	A	15	254.50	31.500	.002
	B	15	151.50		
TUG	A	15	118.50	27.500	.001
	B	15	287.50		

Table 3: Comparison of post LEFS and TUGT scores of experimental group & control group.

Above tables (Table 1, 2) showed differences in pretest and post test values of LEFS and TUGT in Group A and Group B. Although there was difference in each group, the Group A showed statistically significant difference after intervensions. Therefore the study rejects the null hypothesis and accepts the alternate hypothesis.

DISCUSSION

The aim of this study was to determine the effect of Multisensory exercises on reducing the number of falls and improving physical function in Neuropathic patients with type 2 Diabetes.

Many studies had shown that there is significant association between DN and balance impairment and the degree of impairment. In a study by Bogdan Timer et al[31] (2016), they proved that DN is associated with impaired balance and with a consecutively increase in the fall risk in patients with DM. The diabetic peripheral neuropathy and consequent balance problems can achieve better balance and stability through progressive balance training by giving emphasis on the anterior-posterior neuromuscular elements of stability. These patients were more reliant on visual inputs, which cause them greater balance problems during closed-eye tests. This study suggests more emphasis on closed-eye exercises and my

study is in accord with this evidence. Steven Morrison et al[32] in a study showed that type2 diabetic older individuals are at increased risk of fall. Following balance training, the type2 diabetic group demonstrated improvements in balance, Proprioception, lower limb muscle strength, joint mobility, gait speed, reaction time, and consequently, decreased risk of falls. These findings are in support with my study.

A review by Xi Pan et al[33] pointed out that lower limb strength training , vestibular training, proprioception training and mixed sports training could enhance balance and reduce its fall risk in elderly with DPN. Also due to the safety and effectiveness, in elderly patients, Proprioceptive training can be applied to moderate to severe neuropathy.

Apart from balance exercises, sensory exercises are very much helpful in improving balance. In studies by Aly et al[34] and Emam et al[35] showed that in all balance indices, patients with diabetic neuropathy had weaker stability measures compared with nondisabled subjects. They also demonstrated that balance can be improved using visual inputs among these patients. Vibration and passive tactile cues have been used to activate the sensory afferent system to improve balance in diabetic patients[27]. Exercise therapy, including balance exercises, leads to increased oxygen pressure in the lower limbs, skin, and chests of diabetic patients thereby improving skin blood flow[26]. These studies proved that increased sensory stimulation can improve balance in patients with diabetic neuropathy and thus this evidence helped me to link balance with multisensory exercise.

Exercise interventions, in the form of MS exercise programmes, were considered as a new strategy to improve physical function. A growing no: of studies had shown that sensory exercises have effect in balance and gait. In the study by Fábio Marcon Alfieri et al[36] (2012) had explained the fact that MS exercises were able to reduce body sway in elderly. This training provided sensory stimulation of the visual, vestibular, and somatosensory systems through exercises that were performed on different types of surfaces, textures and densities. Furthermore, they used balls, circuits, and other devices that provided stimuli that enhance balance. Walking on different surfaces, which are shown to generate an important proprioceptive input for maintenance of attitudes of body parts between each other. Thus balance and posture were improved. They had done another study in (2010)[37] in elderly and found effect of multisensory in functional mobility. Another study conducted in diabetic neuropathy patients by Nizam Abdul Majeed Kutty et al[38] (2013), showed that the physical therapy approach using multisensory stimulation showed a highly significant improvement in the balance and gait when comparing the pre-test and post-test results. They mentioned that to maintain static balance, the postural control system integrates information from the visual, vestibular, exteroceptive and proprioceptive inputs and changes in anyone increased the risk of falling. Separate somatosensory, visual and vestibular inputs comprise the primary sources of information that contribute to postural orientation. The results of above studies are in accordance with the findings of my study.

As the clinical trials investigating the effect of complications of type 2 Diabetes have shown that the reduction in balance increases risk of fall and reduced functional capacity, there arise the need to point out whether the multisensory exercises that are used to improve balance and gait in many studies have any effect on fall risk and physical function. The outcome measures that were thought to be effective to determine the improvement in physical function was LEFS and to determine the reduction in no: of falls was TUGT.

To confirm, this study was done a sample of 30 diabetic persons was recruited with respect to inclusion and exclusion criteria. Those who agreed to participate in the study were given

individual appointments, at which time the informed consent document was signed and baseline evaluation performed. After participants underwent a clinical examination, they were randomly allocated to either the intervention group or the control group. All outcome measures were assessed at baseline, and after 6 weeks. All subjects well tolerated the interventions and no one dropped out of the study.

15 of them were allocated to the intervention group and 15 to the control group. The experimental group was submitted to multisensory exercise training thrice a week for 30 minutes, over 6 weeks. Both groups received health education on diabetes for 30 minutes each week, for 6 weeks. In this experimental group, subjects performed warm-up activities, balance exercises with eyes open and closed, different speed, in various distances, varied ground surfaces and also including various challenges from obstacles. The control group was submitted to balance exercises training thrice a week for 30 minutes, over 6 weeks. In control group subjects performed various types balance exercises. The both experimental and control group subjects underwent assessment using outcome measure outcome measure before and after 6 weeks of the study using LEFS to know the improvements in physical function and TUGT to know the reduction in number of falls. After taking pretest and post test values of LEFS and TUG test statistical analysis was done.

Using Microsoft Excel, data was converted into SPSS (Statistical Package for Social Sciences) format for analysis. SPSS version 16 was used. The pretest and post test values of both group was compared using Wilcoxen Signed Rank test. Post test values of both group (group A and group B) were compared and statically analysed using MannWhiteny U test.

The LEFS has been found to be a very valid instrument in the measurement of function in the lower extremities. A study by Yeung et al.[35] to assess the reliability, validity and responsiveness of the lower extremity functional scale for inpatients of an orthopaedic rehabilitation ward found that interclass correlation coefficient of LEFS was 0.88.The pretest and post test values of LEFS for experimental group was compared, analysed .Based on the statistical analysis, the experimental group (group A) showed a pretest mean value with standard deviation 48.23±2.421and of posttest mean value with standard deviation was 55.69±5.154 with a Mean difference of 7.46 , z value -3.193 and p value 0.001. Thus the result showed that there is statistically significant difference between pretest and posttest values of LEFS in experimental group.

Then pretest and post test values of LEFS of control group was taken and analyzed. Based on the statistical analysis in Control group (group B), pretest mean value with standard deviation of BBS was 48.67±1.799 and of posttest mean value with standard deviation was 51.87±1.685 with Mean difference was 0.114, z value was -3.424 and p value was 0.001 and the test result showed that there is statistically significant difference between pretest and posttest values of LEFS in control group.

Then the comparison of post test values of LEFS of experimental group and control group was done and based on the statistical analysis, the mean rank for group A was 19.58 and for group B was 10.10. The sum of ranks for group A was 254.50 and for group B was 151.50. Mann Whitney U value was 31.500, the p value was 0.002.The result of the study shows that there is a statistically significant difference between the posttest mean rank of LEFS in group A and group B .The posttest mean ranks of LEFS shows that experimental group (Group A) shows significant improvement in Functional Activities than in control group (group B).Therefore the study rejects the null hypothesis and accepts the alternate hypothesis.

The reduction in fall risk was determined using TUG Test. The timed up and go test (TUG) is a clinical tool that is widely used to assess functional balance and mobility, primarily in older adults. In the study by Steffen et al, 2002 TUG was proven to have good inter-rater reliability and also Good test-retest reliability have been demonstrated in many studies. In many studies that have studied about fall risk , TUG Test had been used.

In this study also pretest and post test values of both groups were taken. Then pretest and post test values of TUG Test of experimental group was compared and analysed. Based on the statistical analysis in experimental group (Group A), pretest mean value with standard deviation of TUG was 13.9615 ±.57379 and of posttest mean value with standard deviation was, 10.5538±1.49979 with Mean difference 3.4077, z value -3.184 and p value 0.001.The test result shows that there was statistically significant difference between pretest and posttest values of TUG in experimental group.

After that, pretest and post test values of TUG test of control group was taken ,analysed .Based on the statistical analysis in control group (Group B),pretest mean value with standard deviation of TUG was 13.7733 ± .48766 and of posttest mean value with standard deviation was, 12.2533±.75957 with Mean difference 1.52, z value -3.413 and p value 0.001. The test result shows that there is statistically significant difference between pretest and posttest values of TUG in control group.

Then post test values of TUG Test was taken and compared. Based on the statistical analysis, the mean rank for group A was 9.12 and for group B was 19.17.The sum of ranks for group A was 118.50 and for group B was 287.50. Mann Whitney U value was 27.500, the p value was 0.001.The result of the study shows that there is a statistically significant difference between the posttest mean rank of TUG in group A and group B .The posttest mean ranks of TUG shows that experimental group (Group A) shows significant improvement in reduction in no: of falls than in control group (group B) Therefore the study rejects the null hypothesis and accepts the alternate hypothesis.

Thus the statistical analysis showed that experimental group A which underwent multisensory balance exercises showed more improvement in reduction of no: of falls and improvement in physical function compared to control group B which underwent balance exercises alone. This proves the effect of multisensory exercises in reducing number of falls, and improving physical function in subjects with diabetic neuropathy.

Limitations of the study

Small sample size; motor and biomechanical components was not considered; long term effect of exercises was not taken into account; body mass index was not included; duration of diabetes was not mentioned.

Recommendation

Additional studies are expected by including larger sample size; younger age group; women as major population; in severe DPN; adding motor and biomechanical components of balance; effect on social advantage, QOL; adding both indoor and outdoor training; with an increased follow-up period.

CONCLUSION

The current study was to find the effect of Multisensory exercise in improving physical function and reducing number of falls in diabetic peripheral neuropathy. Three days in a week for 6 weeks of multisensory training for experimental group and balance exercises for conventional group was performed for the study.

Based on the statistical analysis, the result of the present study shows that there is statistically significant difference in physical

function and number of falls between pre-test and post-test in both group. Experimental group shows greater improvement in physical function with LEFS and number of falls with TUG.

After analyzing this study, the following conclusions were drawn that multisensory exercises is effective in improving physical function. It is also effective in reducing number of falls; Thus the study concluded that multisensory exercise can improve Physical Function and reduction in number of falls in subjects with peripheral neuropathy in type 2 Diabetes.

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