Effectiveness of Multi-Sensory Stimulation Approach on Balance Outcome in Diabetic Neuropathic Patients

Hoda M. Zakaria, Ph.D., P.T* and Sherin Hassan Ph.D., P.T and Sahar M. Adel, Ph.D., P.T*****
*Department of Physical Therapy for Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University.
**Department of Physical Therapy for Internal Medicine and Geriatrics, Faculty of Physical Therapy, Cairo University.
***Department of Physical Therapy for Basic Science. Faculty of Physical Therapy, Cairo University.

ABSTRACT

Purpose: *The purpose of this study was to determine the effect of multi-sensory stimulation approach on pain, restoring balance and consequently reducing the risk of falls in diabetic neuropathic patients.* ***Subjects:*** *Twenty four diabetic neuropathic patients participated in this study (14 female and 10 male). Their age ranged from 40 to 55 years with mean age of (45.42±5.26). All patients suffered from pain, weakness of lower limbs, postural instability, and unsteadiness of gait.* ***Procedures:*** *Multi-sensory stimulation approach were delivered (transcutaneous electrical nerve stimulation, tactile stimulation, proprioceptive stimulation) for 60 minutes three times per week for six weeks. Patients were assessed three times, before initiation of the treatment, after the end of the treatment and one month after termination of the treatment. Balance performance were assessed using Biodex Stability System, Functional reach test, Timed get up-and-go test. The patient's pain was graded by the visual analogue scale, and pain and discomfort level.* ***Results:*** *Statistical analysis revealed that there was a significant improvement in all variables.* ***Discussion and conclusion:*** *The clinical observation suggests that the designed approach was an effective treatment modality in reducing pain, improving balance and consequently; decrease the incidence of falls in diabetic neuropathic patients.*

Key words: *Multi-Sensory Stimulation, Diabetes Mellitus, Peripheral Neuropathy, Biodex Stability System.*

INTRODUCTION

Polyneuropathy is the most common complication of type II diabetes, occurs in the distal extremities and typically affects sensory, motor and autonomic system[3]. The most common form of sensorimotor diabetic neuropathy is distal symmetric polyneuropathy. It affects mainly the feet. The course is chronic and progressive. The symptoms of sensorimotor neuropathy are muscular symptoms: as muscle weakness, atrophy, balance problems, ataxic gait and sensory symptoms (pain, paresthesia, numbness, cramping, nighttime falls)[2]. The steadiness of the subjects with diabetes was less than that of normal one[15,16].

Patients with long standing diabetic peripheral neuropathy suffer marked affection of lower limb proprioception and often develop balance problems that can significantly increase fall risk[5]. Diabetic neuropathic patients have significant deficit in tactile sensitivity, vibration sense, lower limbs proprioception and kinesthesia[11]. Long lasting hyperglycemia as well as impaired proprioception and extroception induced disturbed body balance and locomotor activities[6].

Postural control mechanisms are depending on feedback system. This system is based on postural sway information detected from visual, vestibular and peripheral receptors[14]. Somatosensory information from the lower extremities is one of the main input sources that ensure and regulate postural control[19]. Somatosensory information from periphery plays a key role in balance control especially in absence of visual or vestibular cues. These inputs are derived from extroceptors in skin of the sole of the foot and proprioceptors in other ligaments tendons and joint structures of the foot and ankle[13]. To maintain standing balance the postural control systems integrate information from the visual, vestibular, extroceptive, and proprioceptive inputs and changes in any one increases risk of falling[11]. The postural instability in diabetic peripheral neuropathies usually attributed to the lack of accurate proprioceptive feedback from the lower limbs[20].

Prevention of positive neuropathic sensory symptoms deserve attention because symptoms are troublesome, create anxiety and depression; interfere with work, activity of daily living, meeting family and social responsibilities, attaining adequate rest and sleep, and hindering patients to see their medical providers[1]. Multi-sensory stimulation approach is a therapeutic program using sensory stimulation to help sensory-impaired patients recover functional sensibility in the damaged area and learn adaptive functioning. It helps patients with various forms of sensory loss and impairment retrain their sensory pathways, adapt to changed abilities, and regain function[9]. Therefore this study was designed to determine the effect of multi-sensory stimulation approach on pain, restoring balance and consequently reducing the risk of falls in diabetic neuropathic patients.

MATERIAL AND METHOD

Subject

Twenty four diabetic patients were recruited from El Kasr El-Aini hospitals, Cairo University (14 females and 10 males). Age ranged from 40 to 55 years with mean age of (45.42 ± 5.26) years. All patients are clinically diagnosed as having peripheral neuropathy of diabetic origin and confirmed with electrophysiological studies. These patients complained of burning pain with paraesthesia in both legs. All patients were stable regarding control of their diabetes and their medical management was unchanged during the study period. Strength of lower extremities were not less than grade 3 and all patients had ability to walk at least 10 meters without assistance or assistive device. Exclusion criteria included: Pregnancy, cardiac arrhythmias, cardiac pacemakers, infections and ankle deformities or injuries.

Evaluation procedures

1) Biodex Stability System (BSS) {Biodex Corporation, Shirly.NY,USA} was used to assess overall stability index (OASI) of the patients (the stability is believed to be the best indicator of the overall stability of the patients to maintain balance, in which the larger the stability index value, the greater the degree of instability[22]. Patient was instructed to stand up on the foot platform, grasp the support handles at the beginning of the test ,and to leave it as the test proceeded. Test duration was set for 30 seconds for three successive trials at level eight (the most stable level). The patient was asked to try to maintain a centered position on the platform once the platform was set in motion. This achieved through keeping the cursor on the visual feedback screen in the center.

2) Functional Reach Test (FRT): This test evaluated the anticipatory balance control with

anterior movement[7]. The patient was instructed to raise the arm forward at 90° from trunk (position 1) beside a wall. The baseline measurement was recorded using a leveled yardstick attached to that wall beside the patient, the patient then, was asked to reach as far forward as possible (leaning the trunk forward) with the arm without taking a step (position 2). Distance between position 1 and position 2 (started from apex of the middle finger in position 1 to the same finger in position 2) had been receded as the functional reach score.

3) Timed get-up-and-go test: This test evaluated the functional balance during gait and standing[7,18]. The patient was seated on a chair as a starting position, then asked to stand up, walk 3 meters, turn around, return and sit again, the total time was recorded to accomplish the task.

4) Patient's pain was graded by the visual analogue scale (VAS) and pain & discomfort level. VAS is a ten-point scale where zero refers to no pain and ten refers to maximal pain.

5) The pain & discomfort level (PDL) was graded on a scale of 0-5 on the basis of the patients description and frequency of pain, sleep disturbance due to neuropathic pain and the functional impediment[10].

Treatment procedures

A well planned multi-sensory training program was applied for six weeks three setting weekly for one hour each setting which, included:

- Transcutaneous Electrical Nerve Stimulation {TENS, Mason medical products, NY} was applied to the lumbar region: high frequency TENS was delivered via two electrodes half inch lateral to the right and left posterior superior iliac spine on the back. TENS was given by portable dual channel that generates asymmetrical biphasic square pulse waveform with a pulse width 40-260 and pulse rate 2Hz-120 Hz. The skin was prepared by gentle cleaning it with alcohol wipe. Two self-adhesive surface electrodes 2-inch square were placed half inch lateral to the right and left posterior iliac spine on the back. TENS was set at constant frequency 80 Hz. Each session lasted for 15 minutes. the intensity of stimulation was slowly increased until the patient could perceive the stimulation but was not made uncomfortable. This intensity did not produce visible contraction.
- Tactile stimulation by stroking the skin with brush for five minutes.
- Proprioceptive training including:

1- Proprioceptive Neuromuscular Facilitation in form of repeated contraction technique for dorsiflexors of the ankle joint for fifteen repetitions for ten minutes. Each repetition composed of twenty second for holding contraction and another for relaxation.

2- Standing on tilting table for ten minutes (as weight bearing exercise).

3- Balance training on biodex stability system for twenty minutes thus stimulating proprioceptors, in form of :

   a) Bilateral standing with eyes open then closed.
   b) Unilateral standing with eyes open then closed.

Statistical analysis

The arithmetic mean and standard deviation of the mean was recorded pre and post treatment, one way analysis of variance was used to detect variation in the results of repeated measurements. Level of significance was assumed at 0.05 for all analysis.

RESULT

Table (1): General characteristic of patients.

Variable	Study group Mean ± SD
Age	45.42 ± 5.26 (years)
Sex	14 female and 10 male
Height	169 ± 6 (cm)
Weight	74.08 ± 8.05 (Kg)
Body mass index	26.12 ± 3.63
Duration (DM)	7.16 ± 1.74 (years)
Duration (PN)	2.21 ± 1.29 (years)

Table 2 showed that there was a highly significant increase in all variables of the study group P= 0.0001. Comparing the mean of (OASI) pretreatment, post I, and post II, revealed that there was a statistically significant differences between pre (2.92 ± 0.83) and post I (1.78±0.48). Also there was a significant improvement between pre (2.92±0.83) and post II (1.99±0.50). On considering the functional reach test, there was a highly significant improvement between pre (18.92±3.38) and post I (23.21±3.69) and also between pre (18.92±3.38) and post II (21.46±3.97). In regarding to (TGUGT), there was a statistically significant differences between pre (19.71±3.58) and post I (11.96 ± 2.29). Also there was a significant improvement between pre (19.71±3.58) and post II (13.42 ± 2.12). Comparing VAS there was a significant improvement in pre (7.13±1.51) and post I (3.21±1.74) and a statistically significant improvement between pre (7.13±1.51) and post II (3.75±1.92). In regarding to PDL there was a significant improvement in pre (3.42±0.93) and post I (2.04±0.75) and there was a significant differences between pre (3.42±0.93) and post II (2.29±0.69). There was a non significant differences between post I and post II of all variables as shown in table (2) and figs. (1-4).

Table (2): Comparison between pre, post (I), and post (II) mean values of Balance performance and patients pain shown in table (2).

Variable	Pre	Post (I)	Post (II)	F	P -value
	Mean ± SD				
OASI	2.92 ± 0.83	1.78 ± 0.48	1.99 ± 0.50	22.54	0.0001
FRT	18.92 ± 3.38	23.21 ± 3.69	21.46 ± 3.97	10.416	0.0001
TGUGT	19.71 ± 3.58	11.96 ± 2.29	13.42 ± 2.12	54.045	0.0001
VAS	7.13 ± 1.51	3.21 ± 1.74	3.75 ± 1.92	36.02	0.0001
PDL	3.42 ± 0.93	2.04 ± 0.75	2.29 ± 0.69	20.31	0.0001

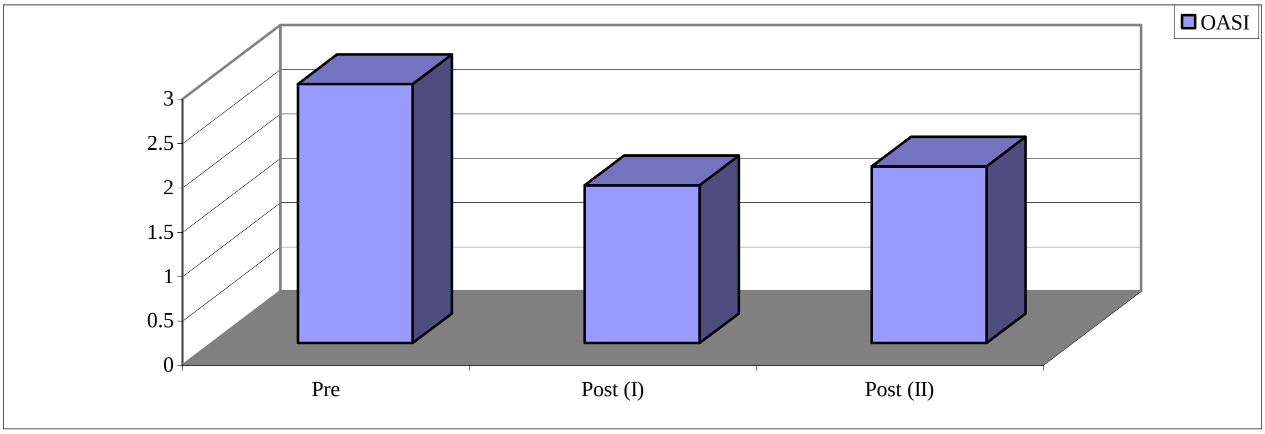

Fig. (1): Comparison between pre, post (I), and post (II) mean values of (OASI).

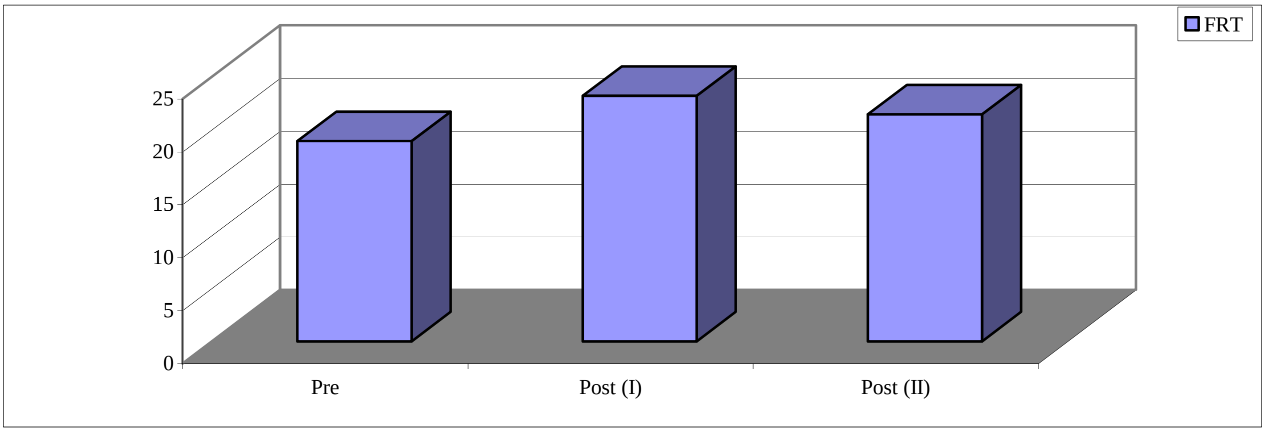

Fig. (2): Comparison between pre, post (I), and post (II) mean values of (FRT).

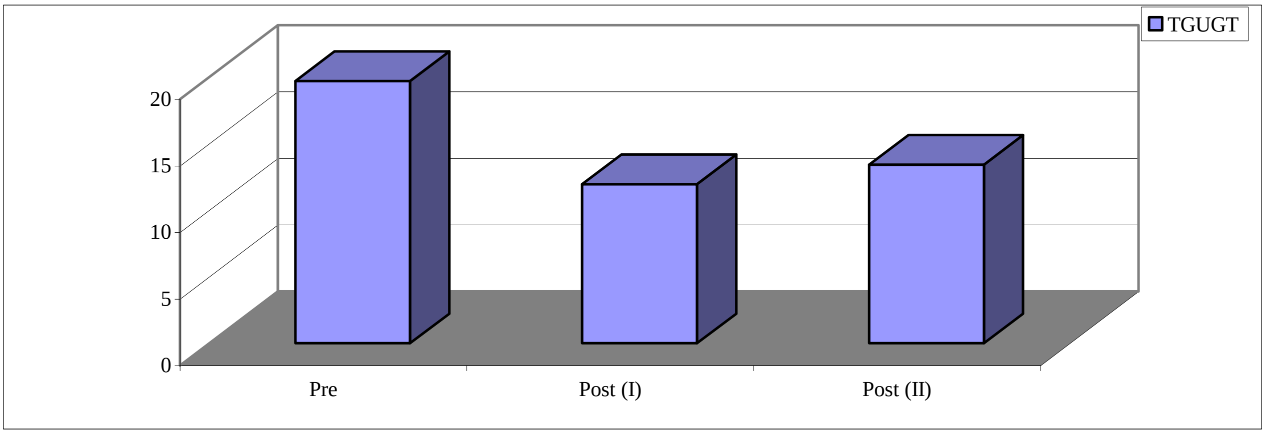

Fig. (3): Comparison between pre, post (I), and post (II) mean values of (TGUGT).

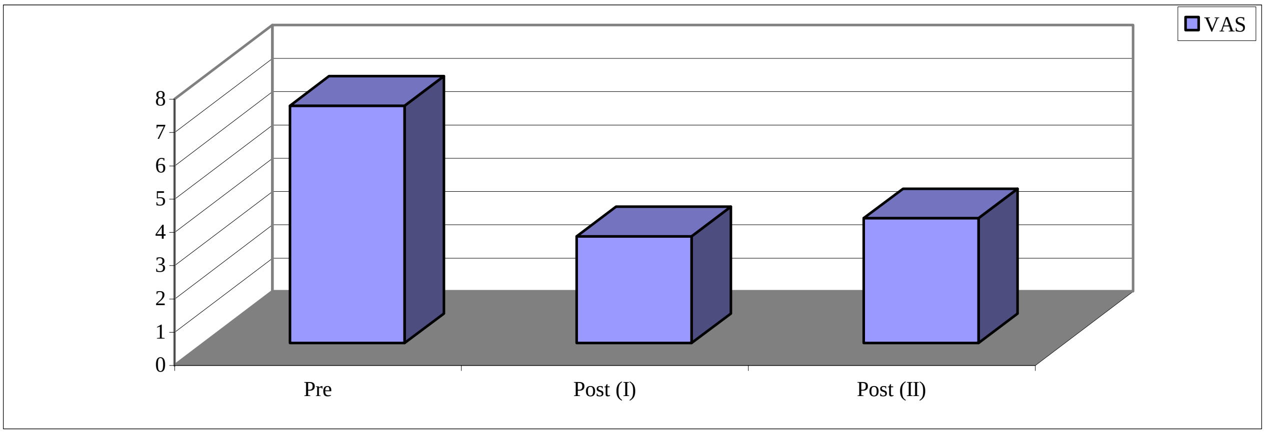

Fig. (4): Comparison between pre, post (I), and post (II) mean values of (VAS).

DISSUSION

The aim of this study was to determine the effect of multi-sensory stimulation approach on pain, restoring balance and consequently reducing the risk of falls in diabetic neuropathic patients. To maintain standing balance the postural control systems integrate information from the visual, vestibular, extroceptive, and proprioceptive inputs and changes in any one increased risk of falling[11].

Multi-sensory stimulation approach uses a variety of therapeutic, rehabilitation, and educational techniques to help sensory-impaired patients recover sensibility, fine discrimination abilities, and the ability to perform other tasks involved in daily living and work activities. In addition to actual loss of sensibility and related functional ability, paresthesias (abnormal sensations), such as numbness, tingling, or burning sensations, may be present. Some of the many possible causes of sensory impairment may include nerve damage, nerve repair surgery, stroke, aneurysm, other forms of central nervous system damage, and diabetes-related nerve impairment[23].

Although diabetic peripheral neuropathy is a progressive disorder; the physical therapy approach using multi-sensory stimulation showed a highly significant improvement in the examined variables when comparing the pre-treatment and post-treatment results up to the follow up period. This may be attributed to the effect of multi-sensory stimulation that may focus on reducing pain through using TENS, providing input to sensory receptors and pathways (tactile stimulation, weight bearing activities), and teaching the patient functional adaptation of new ways of using the abilities they have to compensate for sensory impairments and other disabilities (Biodex balance system training) [17].

The Biodex balance system was used for training of static and dynamic balance of the study group. This system focuses on the proprioceptive neuromuscular mechanisms that appear to affect both static and dynamic balance. The system acts as a valuable training device to enhance kinesthetic abilities that may provide some degree of compensation for impaired proprioceptive reflex mechanisms following injury[21].

The improvement of balance as shown in the improvement of the results of the OSI, FRT, TGUGT) can be explained through biomechanical point of view that motor system generates motor responses according to the mechanical load received by the foot to attenuate the load. Plantar area is the first to touch the floor during standing and plays an extremely important role in supplying the nervous system with pressure and proprioception information[8,13,19].

Given the brevity of the exercise intervention, any strengthening that occurred in the intervention group was more likely related to a synchronization of motor units rather than muscle hypertrophy[12].It is possible that the intervention subjects increased their ankle strength in response to the exercise regimen. Brown et al. [4] found that type II muscle fiber concentration significantly increased in older persons undergoing vigorous strengthening programs. Strengthening has, therefore, been found to occur in response to exercise in diseases such as hereditary motor and sensory neuropathy types I and II.

In general, in addition to actually retraining the senses and nervous system activities, adaptation may be used to help the patient function until full rehabilitation is achieved, but it may also be a permanent adaptation when full rehabilitation is not possible.

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الملخص العربي

فاعلية برنامج مختار للتحفيز المتعدد الحسية على خارج الاتزان في مرضى الاعتلال السكري للأعصاب

الغرض من هذه الدراسة هو دراسة تأثير التحفيز المتعدد الحسية على الألم وإعادة الاتزان وتقليل خطر السقوط في مرضى الاعتلال السكري للأعصاب . وقد تمت هذه الدراسة على عدد أربع وعشرون مريضا يعانون من الاعتلال السكري للأعصاب (14من الإناث و 10 من الذكور) تتراوح أعمارهم بين 40 إلى 55 سنة بمتوسط عمر (45.42 ± 5.26) يعانون من ألم وضعف بالأطراف السفلية وعدم الاتزان وعدم الثبات أثناء المشي . وتم التحفيز المتعدد الحسية باستخدام جهاز التحفيز الكهربائي وتحفيز مستقبلات الأعصاب الحسية والحركية لمدة ستون دقيقة ، ثلاث مرات في الأسبوع لمدة شهر وتم تقيم المرضى قبل وبعد العلاج مباشرة وأيضا بعد شهر من انتهاء العلاج وتم التقييم باستخدام جهاز البيودكس للثبات واختبار الوصول الوظيفي ومقياس مناظر الألم البصري ومستوى مضايقة الألم. ومن نتائج هذه الدراسة وجد زيادة ذات دلالة إحصائية ملحوظة ومرضية في كل القياسات التي تم دراستها في المجموعة العلاجية . ومن هذه الدراسة يمكن الاستعانة بالتحفيز متعدد الحسية في تقليل الألم وتحسين الاتزان وتقليل حادثة السقوط في مرضى الاعتلال السكري للأعصاب .