

Balance Disturbance in Patients with Diabetic Sensory Polyneuropathy

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ABSTRACT

Background: Thirty percent of diabetic patients with polyneuropathy suffer from balance disturbance. Unsteadiness during standing and walking is a frequent complaint in such patients. **Objective:** To evaluate proprioception and vestibular function in patients with diabetic sensory polyneuropathy and to determine the effect of their disturbance on balance in such patients. **Methods:** This study included 60 subjects divided into two groups: group (1): included 30 patients with type 2 diabetes mellitus suffering from sensory polyneuropathy and group (2): included 30 age and sex-matched healthy subjects. All participants were subjected to complete clinical assessment. The dynamic balance was assessed clinically by Berg balance scale (BBS) and laboratory using the Balance Master system. **Results:** Scores of BBS were significantly lower in group (1) than group (2). In addition, Limits of Stability (LOS) test revealed a highly significant increase in the reaction time in all directions, a significant decrease in movement velocity, end excursion and directional control in all directions in group 1 than group (2). Furthermore, a highly significant decrease in the mean values of the SOT was found in group 1 in all conditions. Also, a statistically significant negative correlation was detected between balance score and age in both groups. **Conclusion:** There is an effect of sensory disturbance on balance in patients with diabetic polyneuropathy, which could aggravate the risk of falls in such patients. [Egypt J Neurol Psychiat Neurosurg. 2014; 51(1): 21-29]

Key Words: Type-2 diabetes mellitus, Polyneuropathy, Posturography, Balance, Egyptian patients.

INTRODUCTION

Balance is a complex process in which maintenance of a position is regulated by postural adjustments to voluntary activity and in response to external perturbations¹. Postural control is dependent upon the integration of information from different sensory systems including: vestibular, proprioceptive and visual systems and higher level integrative processes essential for mapping sensation to action and ensuring anticipatory and adaptive aspects of postural control^{2,3}.

The quantitative posturography system is a device that identifies changes in the postural control system and can detect small changes in subjects' ability to maintain their balance. The Balance Master System is a laboratory method for assessment of balance. It determines the relative importance of various sensory inputs critical to balance, as vision, vestibular sensation and proprioception⁴.

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Diabetes mellitus is considered as the commonest etiology of peripheral neuropathy⁵. In Egypt, 30% of diabetic patients have some form of peripheral neuropathy⁶. Peripheral neuropathy can lead to balance problems through damage to sensory nerves causing problems in feeling any sensory changes and problems determining joint position leading to coordination difficulties⁷. Also, motor nerves damage can cause weakness and frequent falls⁸. Furthermore, foot problems, including foot ulcerations, partial foot amputation and trans-tibial amputations, may exacerbate balance disturbances⁹.

The steadiness in subjects with diabetic polyneuropathy is always less than normal¹⁰. In such patients, the difficulty in controlling balance is greatest in eyes-closed (EC) condition than during eye-open (EO) condition¹¹. Also, they have reduced walking speed, step length and rhythmic acceleration patterns at the head and pelvis¹². Furthermore, they have typically increased postural sway during quiet standing¹³ and many patients have difficulty in maintaining unipedal stance¹⁴.

This study was carried out to evaluate proprioception and vestibular function in patients with

diabetic sensory polyneuropathy and to determine the effect of their disturbance on balance in such patients.

SUBJECTS AND METHODS

Study Design and Population:

This study was conducted on 2 groups:

Group (1) (patient group): included 30 patients with type II diabetes mellitus, having sensory polyneuropathy, who were selected from outpatient clinics of Neurology and Internal Medicine, Cairo University, during the period from October 2011 to December 2012. They included 22 males and 8 females.

Inclusion criteria:

1. Patients with type II diabetes mellitus, according to the criteria proposed by American Diabetes Association (ADA)¹⁵, having diabetic sensory polyneuropathy as evidenced clinically and by nerve conduction studies.
2. Age range from 40-50 years (to minimize the effect of aging process).
3. Body Mass Index (BMI) less than 30 (to avoid effect on balance disturbance).
4. Medically stable and controlled patients (HbA1c ≤ 7).

Exclusion criteria:

1. Other causes of polyneuropathy e.g. vascular, endocrinal, metabolic...etc.
2. Other diseases affecting balance e.g. hemiparesis, ataxia, middle ear disease...etc.
3. Symptomatic postural hypotension.
4. Visual or hearing impairment.
5. Patients receiving drugs that may affect balance (as tranquilizers).
6. Medically uncontrolled and non-cooperative patients.
7. BMI ≥ 30 .
8. Orthopedic or arthritic problems in lower limbs.

Group (2) (control group): Included 30 age and sex-matched healthy subjects.

Methods:

Patients were subjected to the following:

1. Clinical assessment including thorough history taking, full general, and neurological examination.
2. Weight and height measurement to calculate Body Mass Index (BMI)¹⁶:

$$BMI = \frac{\text{Mass (kg)}}{(\text{Height (m)})^2}$$
3. Nerve conduction studies to document the diagnosis of sensory polyneuropathy.

4. Balance assessment:

- a) Berg Balance Scale (BBS)¹⁷: including a set of 14 simple balance-related tasks for assessment of postural stability.
- b) Balance Master System (BMS): It provides an objective and potentially more sensitive measurements of static and dynamic balance performance and assessment of limits of stability (LOS).

Assessment procedures:

- **Step 1:** The Limits of stability Test (LOS): The maximum distance a person can displace his center of gravity (COG), lean his body in a given direction without losing balance¹⁸. It included 8 trials for each patient; each trial lasted for 8 seconds. Five parameters were calculated: Reaction time (RT), Movement Velocity (MVL), Endpoint Excursion (EPE), Maximum Excursion (ME), and Directional Control (DCL).
- **Step 2:** Modified Clinical Test of Sensory Interaction on Balance (mCTSIB): It quantifies postural sway velocity with the patient standing quietly on the force plate, first with eyes open, then with eyes closed, using firm and foam surfaces successively. It consists of three trials for each of the 4 conditions. Each trial lasted 20 seconds.

Statistical Methods

The collected data were statistically analyzed using a Graph Pad statistical software (version 5.0) for:

- The arithmetic mean is an average description of central tendency for the observations.
- The standard deviation is a mean of dispersion of results.
- Unpaired t-test to analyze significant differences in Berg Balance Scale scores, Limit of Stability scores and Sensory Organization Test scores between both groups.
- Pearson rank correlation test to correlate between variables in study group. Values of (r) ranged from 0 (no correlation), 0-0.2 (very low and probably meaningless), 0.2-0.4 (a low correlation that might warrant further investigation), 0.4-0.6 (a reasonable correlation), 0.6-0.8 (a high correlation) and 0.8-1 (a very high correlation)¹⁹.

RESULTS

A) General characteristics:

The general characteristics of groups 1 and 2 are shown in Table (1).

No statistically significant difference was found between both groups as regards age, sex, weight, height, and BMI ($P>0.05$).

The duration of illness in group 1 ranged from 6-12 years with a mean duration of 8.73 ± 1.96 years.

B) Comparisons:

I. Scores of Berg Balance Scale (BBS):

A statistically highly significant difference was found between both groups as regards the mean score of BBS, being significantly lower in diabetic patients (group 1) (Figure 1).

II. Parameters of Limits of Stability (LOS):

A statistically highly significant increase in the reaction time (RT), in all directions, was detected in group (1) compared to group 2 (P- values were 0.0001, 0.001, 0.02 and 0.005 respectively) (Figure 2).

Moreover, a statistically highly significant decrease, in movement velocity (MV), end point excursion (EPE), maximum point excursion (MPE)

and directional control (DC), was detected in all directions in group 1 compared to group 2 (Table 2, Figures 3, 4, 5 and 6).

III. Parameters of modified clinical test of sensory interaction:

A statistically highly significant decrease was detected in group 1 compared to group 2, in the 4 conditions of the test (Table 3).

C) Correlations:

A statistically highly significant negative correlation was found between age and mean scores of BBS in group 1 and group 2 ($r = -0.7397$, $p<0.0001$, $r = -0.7271$, $p<0.0001$ respectively).

A statistically highly significant negative correlation was found between BMI and mean scores of BBS in group 1 ($r = -0.7377$, $p<0.0001$). While in group 2, no statistically significant correlation was found between BMI and mean scores of BBS ($r = 0.1071$, $p = 0.5733$).

Table 1. General characteristics of patients and controls.

Body measurements	Group 1 Mean±SD	Group 2 Mean±SD	P-value
Age (years)	43.83±2.39	45.47±3.8	0.06
Weight (kg)	72.8±8.06	73.23±7.14	0.83
Height (cm)	165.7±4.59	166.2±3.48	0.63
BMI (kg/m ²)	26.46±2.18	26.48±2.15	0.97

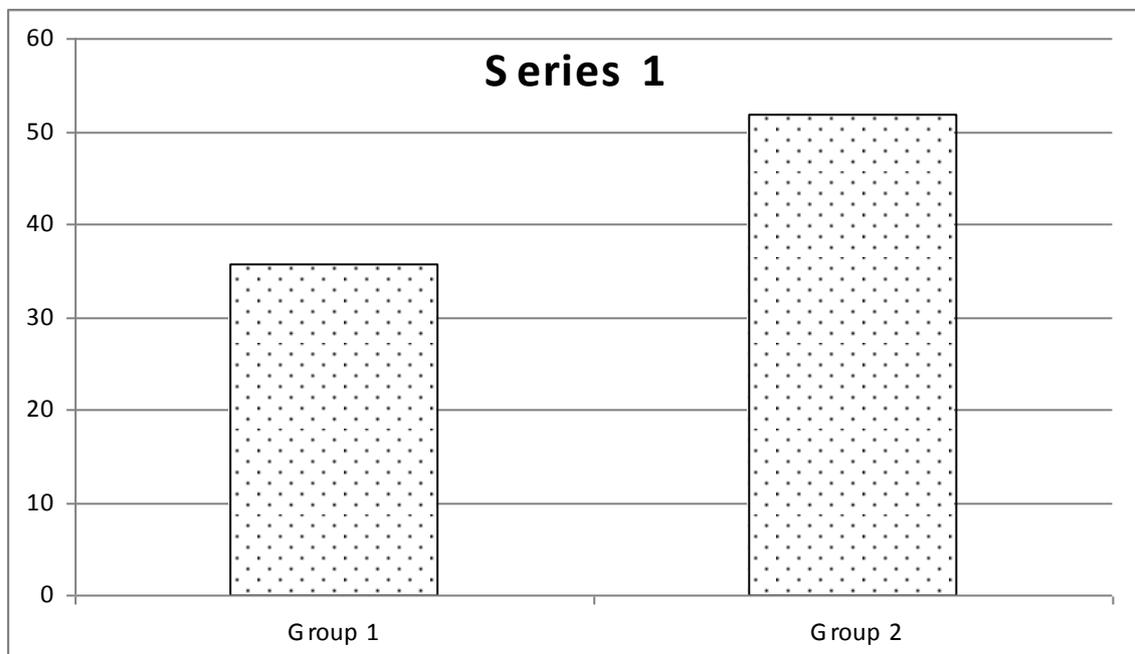


Figure 1. Comparison of scores of BBS between both groups.

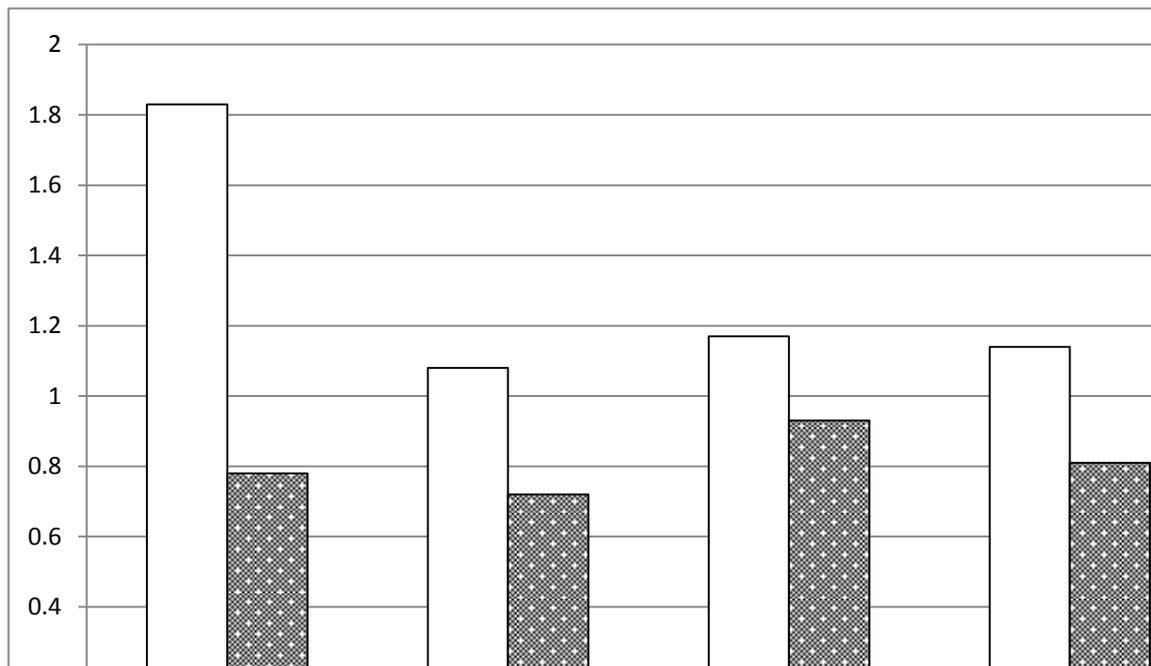


Figure 2. Comparison of mean values of RT in all directions in both groups.

Table 2. Comparison of mean values of MV, EPE, MPE and DC in all directions in both groups.

Tests	Directions			
	Forward	Backward	Right	Left
Movement Velocity (MV)				
Group 1	2.98±0.53	1.77±0.86	3.53±1.19	3.11±0.94
Group 2	5.29±0.87	2.41±0.75	5.025±1.79	5.004±1.65
P-value	0.0001*	0.0035*	0.0003*	0.0001*
End Point Excursion (EPE)				
Group 1	64.17±6.42	36.77±3.78	79.4±6.15	78.4±6.45
Group 2	82.9±3.13	49.3±4.2	83.47±4.73	83.37±4.65
P-value	0.0001*	0.0001*	0.0057*	0.0011*
Maximum Point Excursion (MPE)				
Group 1	65.27±6.79	30.97±4.5	78.43±5.2	78.57±5.57
Group 2	90.23±3.34	59±4.9	100.2±4.45	100.3±4.011
P-value	0.0001*	0.0001*	0.0001*	0.0001*
Directional Control (DC)				
Group 1	71.17±4.87	56.07±6.812	82.93±4.37	81.27±3.423
Group 2	81.93±2.78	62.2±8.036	87.63±6.65	86.8±8.79
P-value	0.0001*	0.0023*	0.002*	0.0022*

* Significant at p<0.01

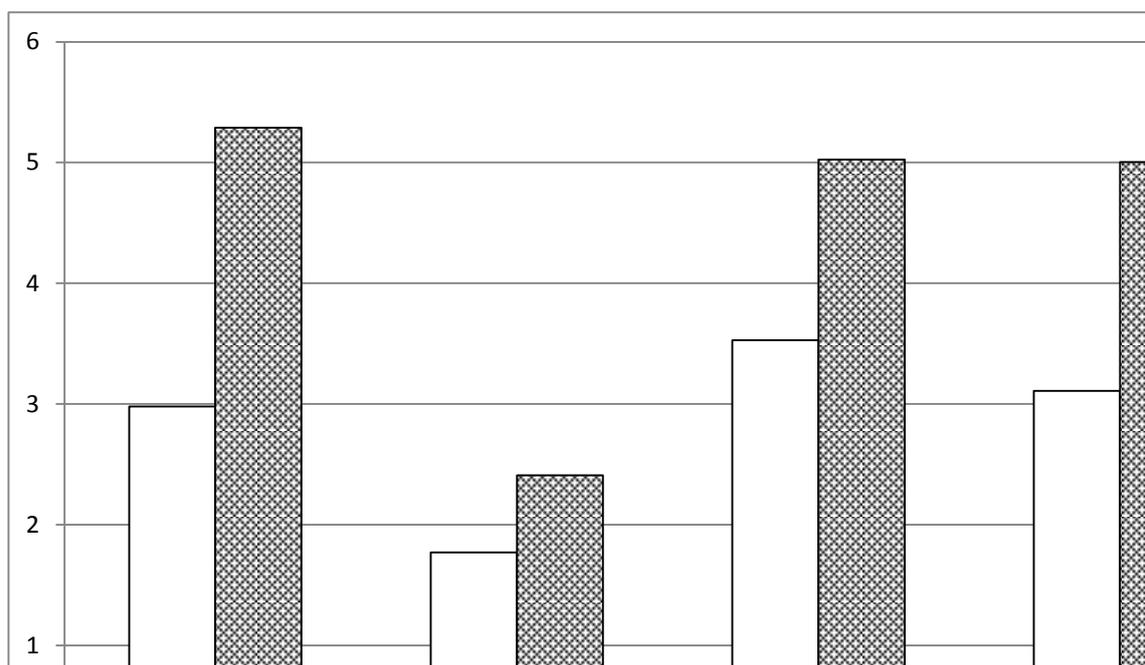


Figure 3. Comparison of mean values of MV in all directions in both groups.

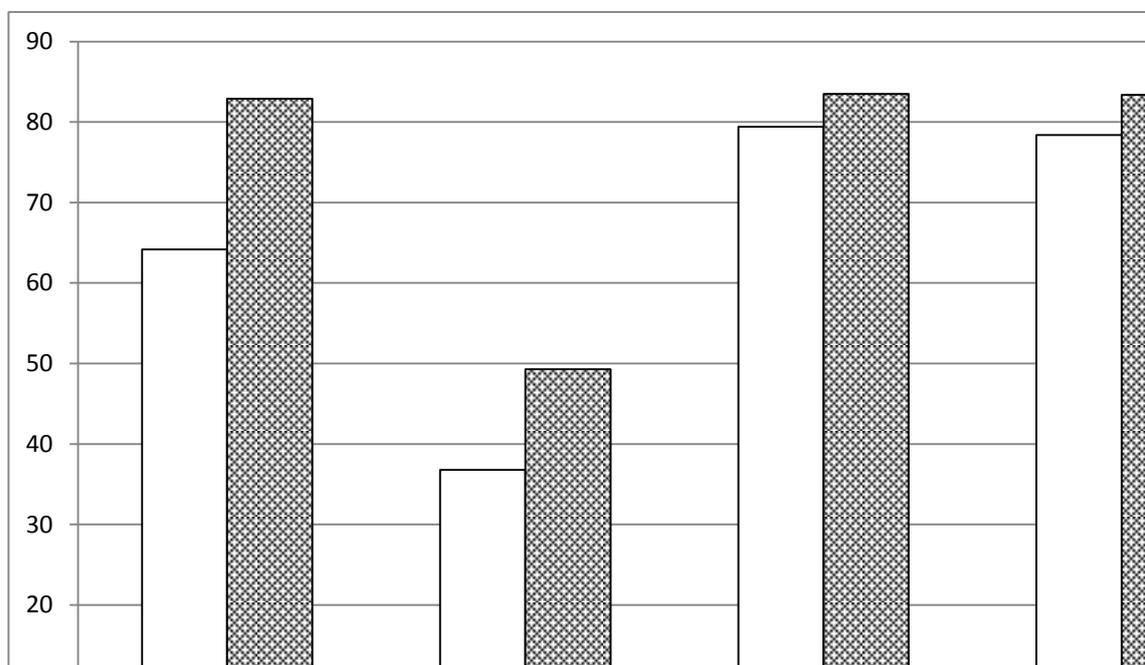


Figure 4. Comparison of mean values of EPE in all directions in both groups.

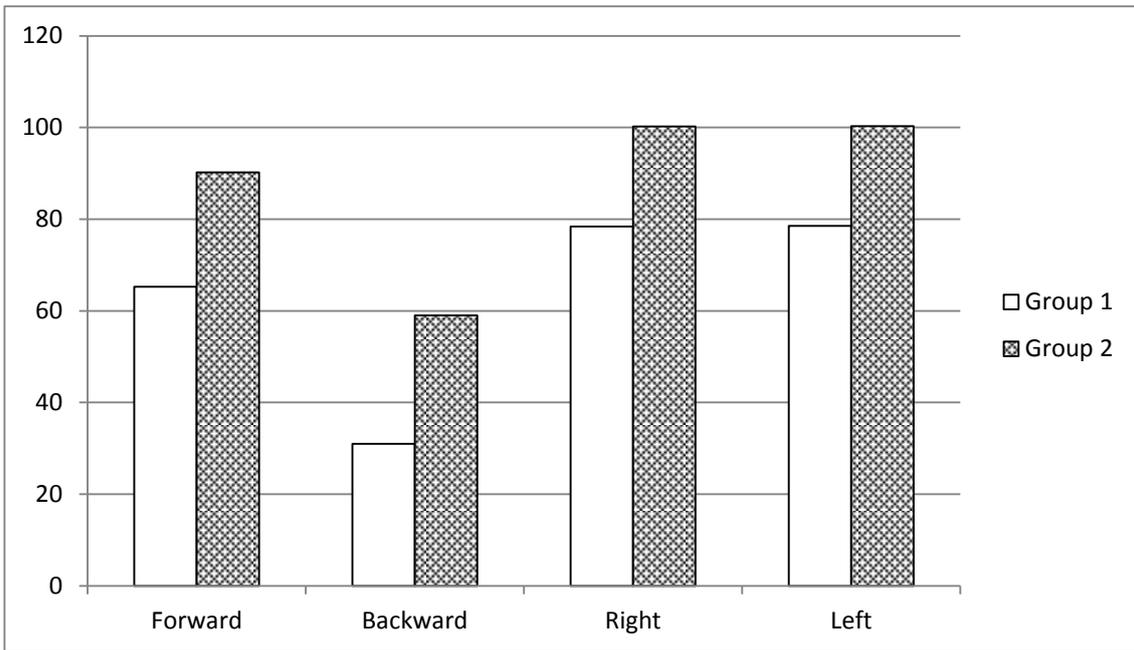


Figure 5. Comparison of mean values of MPE in all directions in both groups.

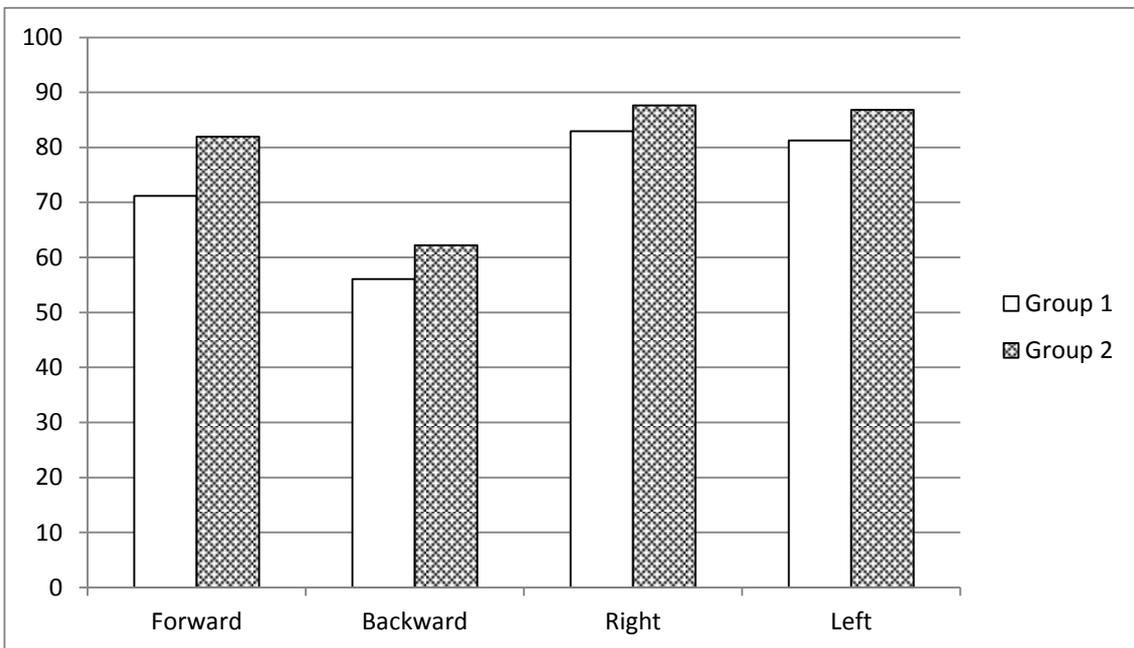


Figure 6. Comparison of mean values of DC in all directions in both groups.

Table 3. Comparison of the parameters of modified clinical test of sensory interaction in both groups.

Equilibrium score	Group 1 Mean± SD	Group 2 Mean± SD	P-value
Eye open, firm surface	88.37±5.72	92.27±4.46	0.0047*
Eye closed, firm surface	78.87±8.16	86.37±9.39	0.0016*
Eye open, foam surface	54.23±3.319	81.6±6.81	0.0001*
Eye closed, foam surface	39.47±5.32	68.73±5.35	0.0001*

* Significant at p<0.01

DISCUSSION

Patients with type II diabetic neuropathy are at an increased risk of falls due to decreased accurate proprioceptive feedbacks and impairment in somatosensory and vestibular systems²⁰.

In the present study, diabetic patients had statistically significant lower scores of BBS as compared to control subjects; indicating the presence of balance disturbance in such patients. This finding agreed with Niam et al.²¹, who found a significant negative correlation between BBS scores and the ability to maintain balance on balance platform in polyneuropathic patients.

Furthermore, this study revealed that diabetic patients had increased body sway during testing parameters on the computerized dynamic posturography indicating significant vestibular dysfunction as compared to the control subjects. These findings agreed with those of George et al.²², who reported that diabetes mellitus may negatively influence postural control and cause impairment of balance with or without the presence of neuropathy. Also, Kim et al.²³, reported that vestibular dysfunction was observed in nearly 60% of diabetic patients with peripheral neuropathy who complained of dizziness.

Involvement of proprioceptive system is another cause of balance disturbance in diabetic polyneuropathic patients¹¹. In this study, disturbance of proprioception was evidenced by the increase in postural sway when visual information was deprived; indicating that such patients depend on visual information for the regulation of posture, which was also previously reported by Flores²⁴.

The present study revealed that affection of foot sensation and proprioception in diabetic polyneuropathic patients may affect the result of Limit of Stability test (LOS) and postural stability examination. These results matched with those of Menz¹², who reported that loss of cutaneous or deep sensation may lead to impaired postural control and increased risk of falling and instability.

In the current study, we observed that patients' falls may occur not only in the forward direction but

also in the side and backward directions, which agreed with the reports of other studies²⁵⁻²⁷.

Diabetic patients also showed a significant increase of reaction time and decrease of movement velocity; indicating the presence of sensory perceptual deficits (slow perceptual processing) and motor planning deficits (slow motor processing). Such observations were also reported by Robinson et al.²⁸. Furthermore, diabetic patients took a longer time to complete the LOS test which was also reported by others^{29,30}.

In the current work, diabetic patients showed significantly lower scores of MPE than control subjects; indicating less ability to accurately preplan movements and doing a lot of extraneous movements to reach the target which reflects incoordination. These findings agreed with Sawacha et al.³¹, who found that diabetic polyneuropathy has an effect on gait, movement excursion and posture, resulting in alterations in gait and movement excursion.

In this work, we applied modified sensory organization test to assess the patient's ability to effectively use visual, vestibular and somatosensory information for maintaining balance in progressively more challenging tasks. In both condition one and two, diabetic patients had statistically significant lower equilibrium scores and more postural sway than control subjects. Such findings were previously reported by other studies^{11,13,32,33}. In condition three, diabetic patients showed a significant increase in body sway when standing on the foam platform; as they were dependent on somatosensory inputs. This finding supported the results of Dickstein²⁰, who concluded that antero-posterior and medio-lateral body sway and trunk velocity were larger in diabetic patients with somatosensory loss than in healthy subjects, especially when standing on the foam surface even with eye open. Also, in condition four, patients became unstable during standing on foam surface and vision was absent, which was also previously reported by Aranda et al.³⁴.

In the present study, we could elicit a statistically significant negative correlation between balance score and each of age and body mass index. This agreed with the results of Johnson³⁵, who showed that among

elderly people, there was a negative correlation between age, balance and independence level. He suggested that elderly people had reduced ability to control their posture, which may predispose them to increased risk of falling. Furthermore, Southard⁹ showed that there may be increased risk for falls with increases in BMI (in obese subjects).

Conclusion

Sensory disturbance has an effect on balance and consequently postural stability in diabetic patients suffering from polyneuropathy. Therefore, physical therapy program should include exercise to improve balance and consequently reduce risk of falls in such patients.

[Disclosure: Authors report no conflict of interest]

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الملخص العربي

تأثير خلل الإحساس على الاتزان في مرضى اعتلال الأعصاب الحسية المتعدد في مرضى السكر

تهدف هذه الدراسة إلى تقييم استقبال الحس العميق ووظيفة الدهليز في مرضى التهاب الأعصاب الطرفية المتعدد الناتج عن مرض السكر (النوع ٢) وتحديد العوامل الأخرى التي قد تؤثر على الاتزان في هؤلاء المرضى. أجريت هذه الدراسة على مجموعتين:

- المجموعة الأولى (مجموعة المرضى) شملت ٣٠ من المرضى الذين يعانون من النوع ٢ من مرض السكر مصابون بالتهاب الأعصاب الطرفية
- المجموعة الثانية (المجموعة الضابطة) شملت ٣٠ شخصاً سليماً من نفس المرحلة العمرية والطول والوزن.

وتم إخضاع المجموعتين للآتي:

١. فحصاً إكلينيكيًا شاملاً.
٢. تقييم الاتزان بواسطة مقياس بيرج للاتزان.
٣. تقييم التوازن الديناميكي المختبر باستخدام جهاز تصوير القوام ألياً.

وقد أظهرت نتائج الدراسة الحالية وجود فروق ذات دلالة إحصائية بين مجموعة المرضى والمجموعة الضابطة في كل من مقياس بيرج للاتزان، اختبار متعدد الاتجاهات واختبار المنظومة الحسية. كما أنه توجد علاقة سالبة بين درجة الاتزان وكل من السن ومؤشر كتلة الجسم.

ولذلك لا بد أن تشمل برامج العلاج الطبيعي لهؤلاء المرضى على تمارين للاتزان مما قد يؤدي إلى ثبات أفضل وتقليل خطر السقوط عندهم.