

## Research Article

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# Effects of Skin Stretch Sensory Stimuli on Balance in Patients with Diabetic Neuropathy

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**Aims:** The purpose of this study was to estimate the effects of stretch sensory stimuli on legs skin and upper back on balance in patients with diabetic peripheral neuropathy.

**Methods:** Overall, 17 diabetic patients with sensory neuropathy aged 44.99 ±3.93years old were engaged, to estimate the effects of one session sensory stimuli by kinesiotape on balance. Balance indices were assessed by Biodex Balance System (BBS) and center of pressure parameters were measured with Bertec Force Plate (BFP) on firm and foam surfaces. All tests were done in eyes open and eyes closed conditions in bilateral standing position.

**Results:** There were significant differences in all stability indices under closed- versus open-eyes conditions. In addition, there were significant differences in center of pressure parameters following sensory stimuli while standing on a firm and 15-cm foam surfaces. The sensory stimuli of kinesiotape in the antero-posterior direction under eyes closed condition were significantly greater than the eyes open.

**Conclusions:** Using of kinesiotape in legs and upper back can improve balance abilities of patients with diabetic peripheral neuropathy. Especially it is useful during standing on unstable surface or with problem of the eyes.

**Keywords:** Balance; Diabetes; Kinesiotape; Neuropathy; Sensory stimuli

**Abbreviations:** BBS: Biodex Balance System; BFP: Bertec Force Plate; OSI: Overall Stability Index; APSI: Antero-Posterior Stability Index; LRSI: Left- Right Stability Index

**Introduction**

Lower limb neuropathy is one of the most common neuropathic disorders that are associated with diabetes. Sensory neuropathy which is damage to the sensory nerve can produce numbness, irritation, and pain in the extremities [1]. During normal standing, somatosensory inputs from the legs and feet contribute to postural stability [2]. Peripheral neuropathy, contributing to decreased proprioception and increased reflex reaction time, has been implicated as a possible risk factor for falling. Balance, muscular strength, and endurance are very important factor in fall risk [3]. In Subjects with loss of sensation associated with diabetic peripheral neuropathy greater postural sway exhibition and a higher fall risk are presented [4,5]. People with diabetic neuropathy have balance disorder even with open eyes and falling vulnerability is high among them as well [6]. Proper postural control depends on the spatio-temporal integration of vestibular, vision and somatosensory information. Damage to each of the mentioned systems; increase the prevalence of falls in older age [7]. Aly et al. [8] showed that individuals with diabetic neuropathy compared to the normal subjects had weaker stability measures in all characteristics of balance. They also demonstrated that using visual inputs can help improve balance among these patients. Emam et al. [9] revealed that Patients with diabetic polyneuropathy had significant inadequate balance capability in comparison to patients without neuropathy.

Tatum et al. [10] stated that a variety of exercise forms and techniques are effective to improve balance and functioning during standing activities. Recently it has been shown that in bipedal standing posture, additional tactile sensory input via active light touch of the fingertips reduces center of pressure fluctuations [11,12]. The use of vibration [13,14] and passive tactile cues and their effect

on balance impairments in diabetic patients have been reported [15], but the mechanism for this stabilizing effect is uncertain. However, Jeka and Lackner [16] have suggested that keeping the fingertip in a fixed position generates proprioceptive information regarding arm position and it's helpful to reduce body sway. It is reported that any changes in shear stress and pressure on the soles of feet during standing tasks can stimulate mechanoreceptors to the higher nervous centres which leads to increased balance ability in these patients [13]. Rogers et al. [17] provided evidence that fixed tactile cues at the shoulder and knee can also reduce sway when standing, possibly because this stimulus provides an additional source of sensory input for the detection of sway. Furthermore, additional sensory cues may have some practical use in relation to the development of novel strategies to improve balance in impaired subjects. For example, walking canes have been shown to improve balance in people with diabetic peripheral neuropathy [18], and this beneficial effect is at least partly due to additional sensory input provided by the cane that coming to motor control centers of nervous system [19]. The site of application of the sensory input does not appear to be as important as previously thought [17]. Kinesiotaping can apply as sensory stimuli on skin receptors. Many theories exist on the effects of therapeutic taping as sensory stimuli. Some have included change of position of a physical structure, change in body and proprioceptive awareness [20]. Therefore, the purpose of this study was to determine the effects of

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additional sensory stimuli on legs and back at the balance in patients with diabetic neuropathy.

## Methods

### Study design and patient population

Overall, 17 diabetic patients (type 1 and type 2) with sensory neuropathy aged 44.99 ±3.93years old were engaged from the Endocrinology and Metabolism Institute of Firoozgar Hospital form 6 September 2010 to 5 January 2011, to estimate the effects of one session sensory stimuli by kinesiotape on balance in a before and after study

### Inclusion criteria

Muscle pain, decrease of sensation, joint position sense of thumb, achill tendon reflex, and sensory lose in lower limbs were symptoms of participants in physical examination. Sensory polyneuropathy because of type 1 and 2 diabetic diseases with Nerve Conduction Velocity 37m/s or below it, were included. Also sensory threshold of tibial and sural nerves were meseared by Neurometer modell 11. Tibial and sural nerves sensory threshold of participant had 30% lower than normal population.

**Exclusion criteria:** Patient with severe optic deficit, other neurologic diseases and any orthopedic abnormality were excluded from the study.

### Data collection

Balance indices including the Overall Stability Index (OSI), Antero-Posterior Stability Index (APSI) and Left- Right Stability Index (LRSI) were measured by BBS (Model 945, USA). Center of pressure parameters (total area, mean velocity and phase plane) were measured by BFP (Model 4060-10, USA) on firm and 15-cm foam surfaces. All tests were done in eyes open and eyes closed conditions in bilateral standing position before applying any stimulus. Duration of signal sampling was 30 seconds at the frequency of 100 Hz. The data sequence was banned using a pass filterer with a 10 Hz cutoff frequency that calculated with Excel software.

Then skin stretch sensory stimuli were exerted by a 10x2.5cm piece of Kinesiotape (a kind of standard adhesive elastic band) with 50% stretch. Firstly Kinesiotape implicated above left and right lateral malleolus on posterior legs up to 15cm. Then it implicated on both sides of spinous process of second thoracic vertebrae (T2) till 15cm bellow T2. During any sway on standing position Kinesiotape was slightly stretched against the legs or upper back skin and produced a stretch force. This kind of stretch was thereby insufficient to provide stabilizing effects. All after tests were down immediately after taping, one time with the legs and the second time with the upper back.

### Ethical review

The protocol was approved by the ethical board of the Rehabilitation Faculty. Patients gave informed consent.

|        | Mean (±SD)   | Max  | Min  |
|--------|--------------|------|------|
| Age    | 44.99 ±3.93  | 54   | 39   |
| Height | 164.46 ±8.21 | 178  | 156  |
| Weight | 67.43 ±7.32  | 81   | 49   |
| NI     | 18.00±2.1    | 19   | 15   |
| NCV    | 369.80 ±1.1  | 37.9 | 36.4 |

NI: Neurometric Index, NCV: nerve conduction velocity.

**Table1:**Demographic characteristics of participants (n=17).

|             | Mean ±SD           |                         |                         | P Value Before & legs stimulation | P Value Before & back stimulation | P Value Between Legs & back stimulation |
|-------------|--------------------|-------------------------|-------------------------|-----------------------------------|-----------------------------------|---|
|             | Before stimulation | After legs. stimulation | After back. stimulation |                                   |                                   |   |
| Open Eyes   |                    |                         |                         |                                   |                                   |   |
| OSI         | 2.58 ±0.04         | 2.46 ± 0.12             | 2.53 ± 0.05             | .342                              | .248                              | .095                                    |
| APSI        | 2.31 ± 0.08        | 2.28 ±0.03              | 2.33 ± 0.02             | .283                              | .182                              | .070                                    |
| LRSI        | 1.47 ± 0.10        | 1.4 ± 0.42              | 1.42 ± 0.05             | 0.098                             | 0.12                              | .389                                    |
| Closed Eyes |                    |                         |                         |                                   |                                   |   |
| OSI         | 6.03 ± 0.15        | 5.39 ± 0.64             | 5.85 ± 0.18             | 0.002                             | 0.031                             | 0.029                                   |
| APSI        | 4.45 ± 0.09        | 3.77 ± 0.68             | 4.27 ± 0.18             | 0.002                             | 0.017                             | 0.010                                   |
| LRSI        | 3.95 ± 0.12        | 3.62 ± 0.33             | 3.88± 0.07              | 0.007                             | 0.178                             | 0.021                                   |

OSI= Overall Stability Index, APSI= Antero-Posterior Stability Index, LRSI= Left-Right Stability Index,

**Table 2:** Comparison of stability indices before and after legs and back stimulation.

|             | Mean ±SD           |                         |                         | P Value Before & legs stimulation | P Value Before &back stimulation |
|-------------|--------------------|-------------------------|-------------------------|-----------------------------------|----------------------------------|
|             | Before stimulation | After legs. stimulation | After back. stimulation |                                   |                                  |
| Open Eyes   |                    |                         |                         |                                   |                                  |
| TA          | 1.74 ±0.08         | 1.68 ± 0.06             | 1.73 ± 0.01             | 0.015                             | 0.82                             |
| MV          | 1.58 ±0.02         | 1.52 ± 0.06             | 1.56 ± 0.02             | 0.043                             | 0.28                             |
| PP          | 1.91 ± 0.03        | 1.84 ± 0.07             | 1.89 ± 0.02             | 0.045                             | 0.72                             |
| Closed Eyes |                    |                         |                         |                                   |                                  |
| TA          | 2.34 ± 0.02        | 1.93 ± 0.41             | 2.05 ± 0.29             | 0.02                              | 0.01                             |
| MV          | 1.73 ± 0.01        | 1.69 ± 0.04             | 1.75 ± 0.02             | 0.041                             | 0.35                             |
| PP          | 2.1 ± 0.01         | 2.03 ± 0.07             | 2.11± 0.01              | 0.047                             | 0.43                             |

TA=Total Area, MV=Mean Velocity, PP= phase plane,

**Table 3:** Comparison of force plate parameters before and after legs and back stimulation standing on firm surface.

|             | Mean ±SD           |                         |                         | P Value Before & legs stimulation | P Value Before &back stimulation |
|-------------|--------------------|-------------------------|-------------------------|-----------------------------------|----------------------------------|
|             | Before stimulation | After legs. stimulation | After back. stimulation |                                   |                                  |
| Open Eyes   |                    |                         |                         |                                   |                                  |
| TA          | 10.83 ±0.08        | 8.19 ± 2.64             | 8.56 ± 2.27             | 0.018                             | 0.024                            |
| MV          | 2.85 ±0.11         | 2.65 ± 0.20             | 2.78 ± 0.07             | 0.048                             | 0.59                             |
| PP          | 3.53 ± 0.21        | 3.22 ± 0.31             | 3.41 ± 0.12             | 0.015                             | 0.045                            |
| Closed Eyes |                    |                         |                         |                                   |                                  |
| TA          | 24.52 ± 0.06       | 15.05 ± 9.02            | 18.33 ± 6.19            | 0.008                             | 0.011                            |
| MV          | 4.43 ± 0.60        | 3.81 ± 0.62             | 4.29 ± 0.14             | 0.01                              | 0.37                             |
| PP          | 5.48 ± 0.16        | 4.68 ± 0.8              | 5.23± 0.25              | 0.005                             | 0.04                             |

TA=Total Area, MV=Mean Velocity, PP= phase plane.

**Table 4:** Comparison of force plate parameters before and after legs and back stimulation Standing on foam surface.

## Statistical analysis

The normality was assessed using the Kolmogrov Smirnov test. The data were analyzed using one- way ANOVA to compare means of all tests before and after taping. P-value less than 0.05 were considered as significant level. Data analysis was done using SPSS software version 15.0.

## Results

Table 1 shows the demographic characteristics of participants. The ANOVA analysis showed significant decrease of OSI, APSI and LRSI in subjects' after stimuli with closed eyes in comparison to before test. Its P value was P< 0.002, P< 0.002, and P< 0.007 for legs stimulus and P< 0.031, P< 0.017, and P< 0.178 after back stimuli respectively. Also there were statistically significant differences of all indices (OSI, APSI and LRSI) between legs and back stimuli with closed eyes condition.

Its P value was  $P < 0.029$ ,  $P < 0.01$ , and  $P < 0.021$  respectively. Table 2 shows all results of Biodex balance tests.

There was statistically significant decrease in force platform parameters after legs stimulation on firm surface under closed and open-eyes conditions but the decrease of parameters were not statistically significant after back stimuli. Table 3 shows all results of force platform parameters on firm surface tests.

However total area, mean velocity and phase plane in all conditions were significantly decreased after Legs stimuli in standing on the foam surface. But after back stimuli there was significantly decreased in total area ( $P < 0.024$ ) and phase plane ( $P < 0.045$ ) with eyes open condition, also total area ( $P < 0.011$ ) and phase plane ( $P < 0.04$ ) with eyes closed condition. Table 4 shows all results of force platform parameters on foam surface tests.

## Discussion

Main findings of this study were significant decrease of all balance indices in subjects' after stimuli with closed eyes in comparison to before test. Also significant differences of all indices (OSI, APSI and LRSI) between legs and back stimuli with closed eyes condition. Significant decrease in force platform parameters after legs stimuli on firm surface under closed and open-eyes conditions. Significant decrease of force platform parameters after Legs stimuli in standing on the foam surface in closed and open-eyes conditions. But after back stimuli there was only significant decrease in total area and phase plane with eyes open and eyes closed conditions. This study demonstrates that application of the passive stimuli on the skin of legs and back, especially in eyes closed situation on unstable surfaces, which provides sensory information about body movement during standing, significantly reduces postural sway and force plate parameters in diabetic patients with polyneuropathy. This finding is consistent with report of Jeka and Lackner that tactile stimuli applied to the shoulder and knee could improve stability [16]. Rather than providing a direct stabilizing torque, the stimuli applies a stretch force to the skin, this suggests that the additional sensory input rather than providing a fixed spatial reference frame enhances the detection of movement.

Loss of sensory cues from plantar surface of the foot increases sway indices and force plate parameters in standing position [21,22], so the plantar insensitivity in the neuropathic subjects may contribute to their increased sway [4,5,7-9]. Moreover, the improvement of stability in neuropathic subjects during sensory stimuli is related to sensory inputs from legs and back so that the new additional inputs partly compensate plantar insensitivity. The positive effects of vibration and passive tactile cues on balance in diabetic patients have been reported previously [13,14,15]. The risk of falls in subjects can strongly predict by magnitude of standing sway [3]. Rogers et al. [17] have reported that, stimuli at the shoulder and knee provided similar benefits in reducing body sway and the risk of falling. Despite report of Rogers et al [17], the present study revealed that stimulus from legs was more effective than back on sway improvement in diabetic neuropathy. Its possible reason is that the anteroposterior sway primarily occurs around the ankle joint [23]. Practically, improvements in balance related to sensory stimuli may potentially be achieved through the use of boots or shoes with high heel collars. Lord et al. [3] have reported that the older women exhibit significantly better balance, when wearing lace-up boots that extend above the ankle compared to standard height shoes. They provided evidence by reduced sway and improved leaning ability, while this difference may have been due to the extra mechanical support provided by the boot. It is also possible

that the boots provided additional sensory input regarding to better control of ankle position. Richardson et al. [24] have demonstrated that ankle braces improve gait regularity in people with peripheral sensory loss when walking on an irregular surface, by providing additional sensory input regarding foot placement and leg movement. These studies indicate that the stabilizing effect of tactile cues to improve balance in impaired subjects is an important reason of further investigation to finding of new falls prevention strategies. The stabilizing effects of vision in the anteroposterior direction was more important when the subject's stability was increasingly challenged by the support surface. Therefore we suggest that precaution should be taken when evaluating postural control stability using foam surfaces with different compliance properties.

## Limitations of the present study

The major limitation of the model described here is that it assesses the effects of sensory stimuli in static balance and semi dynamic situations. Whether sensory stimuli are effective in improving balance during dynamic activities requires further investigation. However, recent studies provide indirect evidence that cutaneous input can be used by the brain to control posture during dynamic tasks.

## Conclusion

The results of this study may suggest that sensory stimuli especially in legs as a new sensory source is able to reduce of body sway and improve balance. Its especially occur during standing on unstable surface or with problem of the eyes in Diabetic Neuropathic Patients.

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**Author contributions:** MA had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the analysis. MA and MD conceived and designed the study, undertook the statistical analysis and drafted the paper; IE and SM assisted in study design, collected data and reviewed the paper. All authors reviewed and approved the final manuscript.

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