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Research Article

ASSOCIATION BETWEEN IMPAIRED BALANCE AND POSTURE IN PATIENTS WITH DIABETIC NEUROPATHY: A CROSS-SECTIONAL STUDY

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A B S T R A C T

Aim: To correlate posture and impaired balance in patients with diabetic neuropathy.
Background: Diabetes Mellitus is one of the most common diseases affecting the adult, with Diabetic Neuropathy being the leading complication. Balance and postural control are affected significantly by the presence of neuropathy, which interferes with sensory feedback and proprioceptive mechanisms on joints of the lower limb.
Methodology: A correlational study was undertaken wherein 30 subjects in the age group of 45-65yrs and their Michigan Neuropathy Scoring Instrument (MNSI) score ≥7 were included in the study. The subjects were asked to perform the Timed-Up-and-Go test and the time taken was recorded. In standing position, postural angles were measured using Markus Bader-Ruler (MB-Ruler).
Result: There was a negative correlation between TUG score and craniohorizontal angle (ρ = -0.018) and TUG score and craniovertebral angle (ρ =-0.118) andTUG score and trunk angle (ρ = -0.319), whereas a positive correlation between TUG score and lumbar angle (ρ =0.037) and TUG score and sway angle (ρ = 0.264).
Conclusion: The study concluded that there was no significant correlation between impaired balance and postural deviations in Diabetic Neuropathy patients.

INTRODUCTION

Diabetes is a group of metabolic disorders in which the body experiences a high glucose level, either because there is insufficient production of insulin (the glycolytic hormone produced by the pancreas), or there is a failed response to insulin (insulin resistance), or both. [1]
Patients with Diabetes will experience the classical symptoms of:

- Polyuria – Increased frequency of urination
- Polydipsia – Increased thirst
- Polyphagia – Increased hunger [2]

Diabetes Mellitus is currently one of the most popular subjects in the science of research owing to its steadily increasing prevalence. According to the World Health Organization (WHO)'s Global Report of Diabetes Mellitus (2016), 422 million adults worldwide were living with diabetes in 2014; and in 2012, 1.5 million people died of diabetes. Its complications include conditions such as kidney failure, heart attack, stroke and lower limb amputation.[3]In 2007, India was declared as the diabetes capital of the world, leading the international scenario of diabetes with 40.9 million affected people and if adequate measures are not taken, the number was estimated to ride to 69.9 million by 2025.[4]

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control. Diabetic Peripheral Neuropathy (DPN) is one of the most common complications following Diabetes Mellitus, also known as Chronic Sensorimotor Distal Symmetric Polyneuropathy. An internationally agreed definition of Diabetic Neuropathy states that it is the presence of peripheral nerve dysfunction in people with diabetes after the exclusion of other causes.[5]This occurs because diabetes causes microvascular injury to the vasa nervosum, which is the blood supply to nerves. It is characterized by progressive loss of nerve fibres, which reflects dysfunction in both large and small myelinated as well as unmyelinated fibres. All sensory modalities are affected in DPN and the patients have reduced vibratory and joint position sense, light touch, pin prick and temperature discrimination with depressed or absent ankle reflexes. [6]

Normal posture is greatly influenced by the harmonious working of various systems of the body, such as:

- Muscles
- Postural reflexes
- Eyes (visual feedback)
- Ears (vestibular system)
- Joint structures (proprioceptors, mechanoreceptors)
- Higher centres like cerebral cortex and cerebellum [7]

Individuals suffering from DPNhave impairment ofsuperficial and deep sensitivity of the lower limbs, resulting in a deficientbalance due to the relationship between the sensitivity of the feet andmaintaining postural control.[8]

Diabetic Neuropathy severely decreases the individual's quality of life and the quality of diabetes self-management which worsens prognosis and produces further complications.[9]

Kinemetry, which is the study of body velocities and mechanics, has been used in literature to determine postural deviations, but the tools used to assess thepostural deviations are expensive and inaccessible at a clinical level and employ procedures that require a multi-level approach, research equipment and highly complex data[8], so this study aimed at using a simple yet cost effective measure to assess postural deviation.

The quantified postural deviation obtained post the assessment was used to compare with values of impaired balance to draw a significant correlation, if existent. This was done by meansof photography (also known as photogrammetry), which was done using Markus-Bader (MB) Ruler online software, to give a quantitative result. The method enabled the angular calculations using anatomical reference points, and thus it is a digital, more objective measurement method.[14]Thus the purpose of this study was to use an easy, reliable and cost-effective method to effectively assess posture and use it to correlate with balance in Diabetic Peripheral Neuropathy

MATERIALS

- Michigan Neuropathy Screening Instrument
- (MNSI – Patient Version)
- Chair
- Cone
- Stopwatch
- Plumb line
- Camera
- MB-Ruler (Markus Bader-Ruler)

Fig Assessment of postural deviation using MB-Ruler

Sample Design

Sample size: 30
Sample population: 30 subjects clinically diagnosed with diabetes mellitus and diabetic peripheral neuropathy by MNSI score.

Sampling: Convenient sampling

Study Design

Type of study: Cross-sectional study
Duration of study: 1 year
Place of study: Metropolitan city

Selection Criteria

Inclusion Criteria

1. Participants in the age group of 45-65 years clinically diagnosed with Diabetes Mellitus.
2. Participants with Diabetic Peripheral Neuropathy determined by the MNSI, with a score of 7 or more positive responses.
3. Individuals willing to participate.

Exclusion Criteria

1. History of peripheral nerve injury or damage
2. History of
   a. Autoimmune Diseases: Guillain-Barre Syndrome, Sjogren's Syndrome
   b. Medications: Chemotherapy
   c. Infections: Lyme disease, shingles, hepatitis C, leprosy, HIV
   d. Inherited Disorders: Charcot-Marie-Tooth Disease
   e. Tumors around the nerves
   f. Vitamin Deficiencies: Deficiency of Vitamin E and Niacin
   g. Metabolic Disorders: Hypothyroidism
3. History of any musculoskeletal disorders affecting posture and/or balance.

Procedure

Subjects who were clinically diagnosed with Diabetes Mellitus were screened and were included in the study.
The subjects were asked to sign the consent form.
Demographic data of the subjects were recorded.

Thestudy subjects were made to perform the Timed Up-and-Go Test

A demonstration of the test was performed for the subject prior to the administration of the test. The test was performed by placing a chair at a distance of 3 metres from the cone and the subject were asked to sit straight on the chair.

On giving the "go" signal, the subject got up from the chair, walked to the cone at their normal pace, turned and came back to the chair and sat down again. The time taken by the subject was recorded using a stopwatch which was started when the subject got up and stopped when they sat again.

Postural assessment was done in standing using the traditional plumb-line method of assessment. Reflective markers were placed at the anatomical landmarks that were viewed in the sagittal view and a photograph was taken in standing. The postural deviations at the cervical, thoracic, lumbar and pelvic regions were measured using the MB-Ruler (Markus Bader-Ruler) using the craniohorizontal, craniovertebral, trunk, lumbar and sway angles.The values obtained from the postural assessment and balance using TUG test were statistically analysed.

RESULTS

The mean values of the posture variables and TUG score are as given in Table 1, along with their respective Pearson's correlation coefficients. The data shows a very weak, negative correlation between TUG score and craniohorizontal angle and TUG score and craniovertebral angle, whereas a very weak, positive correlation between TUG score and lumbar angle. A moderate, negative correlation is seen between TUG score and trunk angle, whereas a moderate, positive correlation is seen between TUG score and sway angle.

Table 1 Mean values of the Timed-Up-and-Go Test scores versus the mean values of the angles and their Pearson correlation coefficients.

Angles	Tug score (mean)	Angle values	Pearson's coefficient (ρ)
Craniohorizontal	15.34	19.67	-0.018
Craniovertebral	15.34	44.67	-0.118
Trunk	15.34	10.45	-0.319
Lumbar	15.34	81.22	0.037
Sway	15.34	164.8	0.264

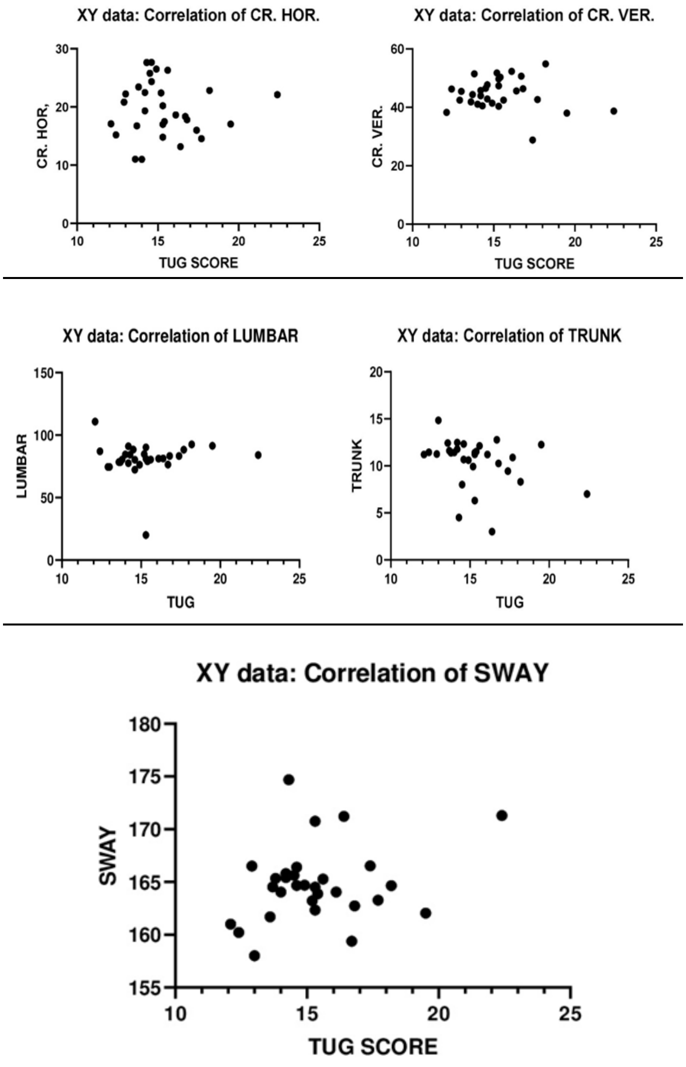

Fig 1 XY scatter plot graph with Timed-Up-and-Go Test score on the X-axis (in seconds) against the 5 postural angles on the Y-axis (in degrees).

DISCUSSION

The current study examined balance and posture in 30 subjects affected by Diabetic Peripheral Neuropathy (DPN) in the age group of 45-65. The population was selected according to the inclusion criteria and the Michigan Neuropathy Screening Instrument (MNSI) ≥7 was used to determine severity of DPN, and an average score of 10.86 was obtained. The subjects were then made to perform the Timed-Up-and-Go Test and time taken to complete the test was recorded in seconds. They were then asked to stand in normal standing and a photograph was taken in the sagittal view, which was assessed for posture using the Markus Bader Ruler (MB-Ruler). 5 angles were measured, namely Craniohorizontal, Craniovertebral, Trunk, Lumbar and Sway angles. Pearson's Correlation Coefficient was applied on the obtained data to draw a correlation between the TUG Test score and each of the angles. It was found that there is negligible correlation between TUG score and all angles except Trunk angle, which had negative linear correlation with the TUG score. This suggests that there is no association between impaired balance and postural deviations in patients with DPN, and the contributing factors to each of them may be disparate.

Ahmmed et al and Salsabili et al in their study suggested that postural sway is significantly affected in DPN patients, in addition to a change in ankle-strategy of postural control to predominantly hip-strategy[15]. Previous studies also demonstrated that in neuropathic postural sway, there is a greater deficiency in their ability to maintain posture and stability[16]. This leads us to infer that postural control is highly influenced by the sensory feedback from the soles of the feet, as well as ankle joint proprioception[17] [18], which are all affected. In addition, the reliability for postural control and fall prevention shifts more towards visual feedback, which has been proved in studies showing notable difference between the eyes-open and eyes-closed postural sway between DPN and non-DPN subjects[19].

A study done by Timar et al shows major association between impaired balance and DPN, both in static and dynamic testing of balance, and also that despite the presence of other contributory factors, DPN can individually affect balance and its severity is directly proportional to that of balance impairment[20]. The study by Brown et al measured the separation of the centre of mass from centre of pressure, and the findings point towards the fact that DPN subjects had the greatest mean separation between the two; this separation poses a higher risk of fall to the individual, as a person's upright standing stability is directly proportional to the how close the centres of mass and pressure are, because when the centre of mass is not directly over the centre of pressure, it starts to impose muscular demands to maintain upright standing[21]. As already discussed by Corriveau et al, DPN subjects show a weakness in muscles like hip flexors and knee extensors[22], thus further contributing to balance impairment owing not only to decreased sensory feedback and centre of pressure, but also weakness of lower limb musculature.

As it has been established by numerous literature over the years, presence of DPN has a consequential effect on the individuals balance and postural control, both being co-dependent. This study observed the association of the aforementioned impaired balance with the static posture of the patient, and it was found that balance has a weak, almost negligible correlation with postural deviations as assessed by TUG score versus craniohorizontal, craniovertebral and lumbar angles. Treleaven at al had proved that there was a weak correlation between standing balance and cervical joint position error (JPE), which is a measure to detect sensori-motor disturbances in the cervical spine[23]. It can be safely implicated that balance would have little to no association with the cranial postural deviations observed by craniohorizontal and craniovertebral angles, since balance impairments in any individual, neuropathic or not, are not directly influenced by changes in the cervical region and vice versa, corroborated by the negligible correlation between the variables. However, a moderate, negative correlation was found between TUG score and trunk angle ($\rho = -0.3185$) and a moderate, positive correlation between TUG score and sway angle ($\rho = 0.2644$). Since trunk angle is a measure of the forward lean of the trunk, the lesser the trunk angle, the more the forward lean [24], and hence decrease in balance which would lead to increased TUG score. The sway angle gives information about the position of the hip relative to the ankle, with an increase suggesting shift of centre of gravity anteriorly, with postural control moving to the forefoot instead of the heel [25]. Thus it can be inferred that increase in sway angle will give rise to increased risk of fall, especially anteriorly, and hence an implied increase of the TUG score.

The study was conducted with the notion that a diabetic neuropathic patient's balance and postural control are not only affected but also correlated, which have been proved by previous literature, and hence the impaired balance could possibly contribute to changes in the patient's general standing posture over time or vice versa. Although these two factors are capable of being mildly associated, it can be said at the end of this study that the correlational findings are almost negligible, thus rendering the relationship between balance and posture insignificant and not definite.

CONCLUSION

The present study concludes that there was no significant correlation between impaired balance and postural deviations existing in Diabetic Neuropathy patients.

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