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A Study to Evaluate the Postural Sway in Type 2 Diabetes Mellitus Patients with Or Without Polyneuropathy: A Cross-Sectional Study

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ABSTRACT

BACKGROUND: Diabetes can cause long-term complications such as retinopathy, which can result in vision loss, nephropathy, which can cause renal failure, peripheral neuropathy, which increases the risk of foot ulcers. The degree of postural instability is anticipated to be higher in diabetic patients with a lengthy history of severe peripheral neuropathy than in non-diabetic people. Patients with polyneuropathy who have type 2 diabetes were unable to maintain an upright posture. There will be the early stage of postural balance impairment.

PURPOSE: To evaluate the postural sway in Type 2 diabetes mellitus patients with or without polyneuropathy.

METHODOLOGY: The total study duration was one and half year. Two groups were taken including Group A with Type 2 diabetes mellitus patients with polyneuropathy and Group B with Type 2 diabetes mellitus patients without polyneuropathy. Patients between the age group of 45-70 years were selected on the basis of inclusion criteria. A minimum of 40 patients were recruited for the study. Dependent variable, postural sway in anteroposterior direction was evaluated on the Orthoking Pressure Plate SDP 610.

RESULTS: Data analysis was performed by SPSS Software version 18 and the variable was compared and assessed using unpaired t-test and Karl Pearson's Coefficient of Correlation. The results of the study showed that there was significant difference between the postural sway (in AP direction) of Group A (DM type 2 with polyneuropathy) and Group B (DM type 2 without polyneuropathy), as the P values of Group A and Group B were 0.0307 (eyes open) and 0.0445 (eyes closed). In both groups (Group A and Group B), the correlation between postural sway (AP direction) between the eyes open and eyes closed conditions was also significant at level 0.05 (two-tailed).

CONCLUSION: From the results of present study it is depicted that there is postural sway with reference to increase in deviation in Anteroposterior direction. Thus it can be concluded that DM Type 2 with polyneuropathy have higher postural sway as compared to the DM type 2 patients without polyneuropathy. Therefore, the results from the present study can be taken into consideration while assessing and treatment planning of patients with DM Type 2 with polyneuropathy.

KEYWORDS: Diabetes, Polyneuropathy, Postural Instability

INTRODUCTION

Diabetes is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Diabetes-related chronic hyperglycemia is linked to long-term impairment, dysfunction, and failure of numerous organs, particularly the nerves, heart, eyes, blood vessels, and kidneys.[1]

The causes of diabetes mellitus are still mostly unknown. These days, it is well accepted that the complex genesis of diabetes mellitus is influenced by both environmental and hereditary variables.[2]

The combination of genetic, environmental, and epigenetic variables leads to the multifactorial, complex illnesses type 1 diabetes and type 2 diabetes. As a result, the effects of type 1 and type 2 diabetes fluctuate depending on the population and factors including age, race, ethnicity, region, and socioeconomic level. A wide range of possible environmental factors, including an obesogenic environment, sedentary lifestyle (i.e., physical inactivity and energy-dense diet), micro biome, drugs, age, sex, and socioeconomic status, have emerged, as epidemiological and clinical data have shown.[3]

The World Health Organization (2003) estimated that by 2030, there would be 370 million individuals worldwide who have diabetes, nearly doubling from the 177 million who did so in 2000. Diabetes prevalence is rising quickly around the world.[4]

TYPES OF DIABETES MELLITUS

1. Type 1 diabetes- (breakdown of b cells, which typically results in a complete lack of insulin) Immune-mediated diabetes. Previously known as insulin-dependent diabetes or juvenile-onset diabetes, this kind of diabetes, which only affects 5–10% of those who have the condition, is caused by an autoimmune response that causes cellular damage to the pancreatic b-cells.[1]
2. Type 2 diabetes- (varying between mostly insulin resistance with relative insulin insufficiency and primarily an insulin secretary malfunction with insulin resistance) Previously known as non-insulin-dependent diabetes, type 2 diabetes, or adult onset diabetes, this kind of diabetes affects people who have insulin resistance and typically have relative insulin shortage. It accounts for 90–95% of people with diabetes.[1]
3. Gestational Diabetes Mellitus (GDM)- Any level of glucose intolerance that begins or is first noticed during pregnancy is referred to as GDM.[1] GDM is the cause of about 90% of diabetes cases and concomitant pregnancy-related issues. GDM affects 1% to 14% of pregnancies; its prevalence is significantly influenced by the communities studied. Ethnicity is known to have a significant impact on this risk. GDM is more common in some racial or ethnic groups than in others.
4. Idiopathic diabetes- Idiopathic diabetes, sometimes referred to as ICA-negative or type 1B diabetes, is a group of diabetes forms that share anatomical similarities with type 1 diabetes but vary in that they are characterized by non-immune β-cell failure without a clear HLA relationship. As a result, they are occasionally treated differently from other types of diabetes. This kind of diabetes is rare and has a distinct hereditary pattern; those who have it are primarily Asian or African-Caribbean.[5]

When combined with typical symptoms including weakness, thirst, weight loss, and fatigue, a persistently increased blood glucose level is used to diagnose diabetes mellitus (DM).

CLASSIFICATION OF DIABETIC NEUROPATHY

1. Focal and Multifocal Neuropathies
2. Proximal Motor Neuropathy and Chronic Demyelinating Neuropathies

3. Diabetic Truncal Radiculoneuropathy
4. Rapidly Reversible Hyperglycemic Neuropathy
5. Generalized Symmetric Polyneuropathy

A. Acute sensory neuropathy

B. Chronic Sensorimotor Neuropathy or Distal Symmetric Polyneuropathy[6]

The phrase "length dependent" describes diabetic polyneuropathy (DPN), a chronic, progressive condition that starts in the toes and feet and gradually spreads to more proximal parts of the limbs. This results in "stocking and glove" signs and symptoms.

Numbness, tingling, and paresthesiae—such as chilly feelings, aching and scorching pains, and so forth—were commonly reported by the patient. Severe shooting pains were reported in over 25% of the patients in both the superficial and deep tissues. The cramps, spasms, and pains were frequently severe in the cold and at night. Rest and sleep were usually unattainable since it was unbearable to touch the bed linens.[7]

Diabetic polyneuropathy (DPN) is the the most frequent consequence of both type 1 and type 1 diabetes. It is also the most common sign of diabetic neuropathies. The combination of diabetic polyneuropathy aftereffects and circulatory deficits in the foot leads to a variety of anatomical and functional problems that are the preconditions for ulcers.

More than 85% of cases with reported PN are caused by chronic injury to the sensory nerve system. Reduced tactile sensation at the foot's sole is the result of long-term harm to the sensory motor system. Reduced tactile sensitivity in the foot sole due to peripheral neuropathy may lead to issues with balance and movement. The severity of the condition increases with worsening gait and balance. Standing balance, but not leg strength, is strongly correlated with decreased functional gait performance in people with Parkinson's disease (PN), as determined by timed-up-to-go tests and 6-minute walks.

Peripheral arterial disease (PAD), diabetic peripheral neuropathy (DPN), and changes in the structure of the foot can all lead to deformities in the feet and increased weight-bearing pressure. Foot ulceration is the crucial and harmful side effects of both Type 1 and 2 diabetic mellitus (DM). Elevated dynamic plantar pressures are frequently observed in diabetics with peripheral neuropathy, which may be a sign of plantar foot ulceration.[8]

Patients with chronic neurological illnesses own a better standard of living and a higher chance of survival when they have gait disturbances and postural instability.[9]

The faulty foot and ankle biomechanics of the diabetic patient are largely due to joint immobility. Within the tendon and capsule of the diabetic patient, structural alterations take place. The tendon, capsule, and ligament

of diabetic patients have an unorganized pattern. Reduced elasticity and tensile strength are the results of these alterations. These modifications either result in subluxations at joints caused by instability or general stiffness of the foot. Poor foot biomechanics occurs in either scenario. Charcot neuroarthopathy, which is characterized by joint subluxations, is an illustration of an unstable diabetic foot.[10]

Complex connections between visual, vestibular, somatosensory, and cerebellar information maintain a steady posture. If there is a motor neuron or sensory neuron problem, an irregularity in the postural sway is predicted. In diabetic individuals, cerebellar disorders and profound sensory disturbances both impact body sway. Individuals with diabetes who have peripheral neuropathy frequently experience deep-sense issues. It is expected that patients with diabetes who have a long history of peripheral neuropathy and

significant retinopathy will be more unstable than non-diabetic individuals. Individuals with type 2 diabetes and peripheral neuropathy were unable to keep their posture straight. The early stages of postural balance impairment will manifest.[11]

Patients with type 2 diabetic neuropathy (DN) are more likely to fall. This increased risk is most likely due to neuropathy and sensory ataxia, which are diseases that impair accurate proprioceptive signals and have been associated to well-documented balance problems. The transition from an ankle-based to a hip-based balancing strategy, a decrease in peripheral sensory information in the feet, and an inability of the central nervous system (CNS) to properly integrate available postural control information are among the causes of instability in patients with type 2 diabetes. Furthermore, because they rely more on visual cues and employ vestibular information, people with DN also have decreased postural control.[12]

When the feet are positioned too tightly together (12 cm or closer), postural sway develops and the ankle muscles, which are less efficient than other muscle synergies, are largely responsible for stability. The mediolateral stance's little but noticeable increase in sway was probably caused by a floor effect. Participants' foot placement tactics may alter and postural stability may be affected differently by extending foot separation in the mediolateral stance.[13]

METHODOLOGY

STUDY DESIGN: Cross-sectional study

STUDY SETTING: Study was conducted in out-patient department of DAVIPTR and its affiliated hospitals.

SAMPLE SIZE: 40 participants were taken.

SAMPLING TECHNIQUE: Subjects were recruited using convenient sampling method.

DURATION OF STUDY: The study duration was one and half year.

SELECTION CRITERIA: All the subjects were selected on the basis of following criteria-

INCLUSION CRITERIA:

- Subjects between ages of 45 to 70.
- The study included participants of both genders.
- Diabetes mellitus type 2 diagnose for at least 7 years.
- A score of 5 or higher out of Michigan Diabetic Neuropathy Score (MDNS) for diabetic peripheral neuropathy
- Not receiving any physiotherapy intervention or off-loading devices (orthotics or footwear modification)
- Subjects who can walk independently.

EXCLUSION CRITERIA:

- Subjects with amputation.
- Subjects with active foot ulcers or open lesions
- Subjects with any other neurological or orthopedic impairment (such as stroke, poliomyelitis, rheumatoid arthritis)
- Subjects with peripheral vascular disease having symptoms of intermittent claudication.

VARIABLES:

Dependent variable: Anteroposterior postural sway

Independent variable: Diabetes mellitus type 2 with or without polyneuropathy

PROCEDURE

The study recruited people who satisfied the inclusion criteria. Two groups were formed: Group A consisted of patients with Type 2 diabetes mellitus who also had polyneuropathy, and Group B consisted of patients with Type 2 diabetes mellitus who did not have polyneuropathy. The barefoot postural sway measurement was taken on the Orthoking Pressure Plate SDP 610. After obtaining the consent, subjects were taken according to the criteria of Michigan Neuropathy Screening Instrument. Then the height, body weight and foot size was recorded. Detection of protective sensation (or to determine the loss of protective threshold) was performed using the standard procedure for 10 g Monofilament Test and assessment of vibration sense was done using Tuning Fork (128Hz). Pressure Plate was used to analyse postural sway in the anteroposterior direction.

STATIC POSTURAL STABILITY

In order to evaluate postural sway under stable surface conditions, participants had to stand on a pressure plate with their legs spread shoulder-width apart and focus for 30 seconds on a dot painted on the wall. It was done with both open and closed eyes.

For postural sway in the anteroposterior direction, at least three trials were recorded. Following that, the average value of three trials was calculated for the parameter which was mentioned above.

Instruction was given to the subjects to stand still and try not to sway much.

Eyes open **Eyes closed**

Measurement of the postural sway

DATA ANALYSIS AND RESULTS

Data Analysis deals with the detailed explanation of the result of the study by converting the raw data into useful information. Evaluation of postural sway in individuals with or without polyneuropathy who had type 2 diabetes was the goal of this investigation. Patients with DM Type 2 who also had polyneuropathy (Group A) and those without polyneuropathy (Group B) were divided into two groups. To assess and compare the postural sway between the two groups, the study evaluated postural sway in

the AP direction in both eyes open and eyes closed circumstances (static and dynamic stability). To test for the difference between groups an independent/ unpaired t-test was applied. Karl Pearson's coefficient of correlation is a widely used mathematical technique that measures the degree of relationship between linearly connected variables using numerical representation. "r" stands for the coefficient of correlation. It was used to find correlation between the postural sway of each group. A level of significance of $p<0.05$ was applied. To illustrate the results of the current study, the data was arranged and analyzed as tables and graphs.

Table 1.1 Shows comparison of mean and S.D of postural sway between Group A and B

Unpaired T Test	Comparison			
	POSTURAL SWAY IN AP DIRECTION (in mm)			
	Eyes Open		Eyes Closed	
	Group A	Group B	Group A	Group B
Mean	3.03	1.28	6.38	2.22
S.D.	3.474	0.405	8.901	0.847
Number of subjects (n)	20	20	20	20
Mean Difference	1.76		4.16	
Unpaired t-test	2.244		2.078	
P value	0.0307		0.0445	
Table value at 0.05	2.02		2.02	
Result	Significant		Significant	

Graph 1.1 Shows comparison of mean and S.D of postural sway between Group A and B

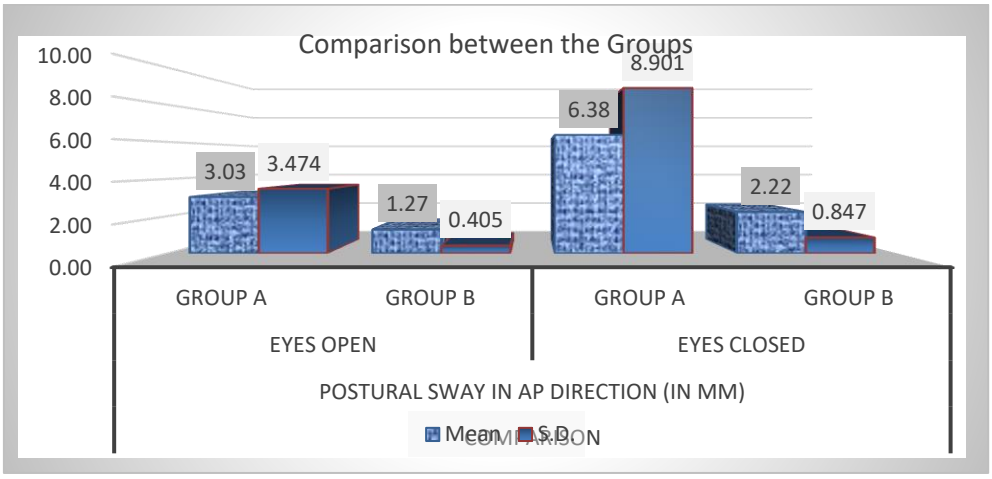

Table 1.1and Graph 1.1 shows that the mean and S.D of the postural sway (AP direction in mm) of group A and group B (eyes open) were 3.03+3.474 and 1.28+0.405 respectively, whereas the mean and S.D of the postural sway of group A and B (eyes closed) were 6.38+8.901 and 2.22+0.847. The mean

differences were 1.76 and 4.16. The t values of 2.244 (EO) and 2.078 (EC) show a significant difference between the postural sway of both groups.

CORRELATION BETWEEN THE VARIABLE OF GROUP A

Table 1.2 shows the correlation between the postural sway in eyes open and eyes closed condition

VARIABLE	KARL PEARSON CORRELATION COEFFICIENT (r)	P VALUE	RESULT
Postural sway in AP direction (EO and EC)	0.901	0.000	Significant

Correlation between the postural sway in eyes open and eyes closed condition (r=0.901) is significant at the 0.05 level (2-tailed).

CORRELATION BETWEEN THE VARIABLES OF GROUP B

Table 1.3 shows the correlation between the postural sway in eyes open and eyes closed condition

VARIABLE	KARL PEARSON CORRELATION COEFFICIENT (r)	P VALUE	RESULT
Postural sway in AP direction (EO and EC)	0.764	0.000	Significant

Correlation between the postural sway in eyes open and eyes closed condition (r=0.764) is significant at the 0.05 level (2-tailed).

From the results it is evident that subjects with DM Type 2 with polyneuropathy showed significant difference with reference to postural sway (deviation) in anteroposterior direction. Thus, the (Group A) DM Type 2 with polyneuropathy showed higher postural sway than DM Type 2 without polyneuropathy (Group B). Additionally, the correlation between postural sway in eyes open and eyes closed conditions was found significant in both groups. The null hypothesis is rejected as a consequence of the current study's results supporting the alternative hypothesis.

DISCUSSION

Diabetes can cause peripheral neuropathy leading to protective sensation loss which results in high, undetected pressure on the plantar aspect of the foot which increases the risk of foot ulcers. It is expected that patients with diabetes who have a long history of peripheral neuropathy and severe retinopathy will have more postural instability than non-diabetic individuals. Patients with polyneuropathy who are at risk of falling and with type 2 diabetes were unable to keep an upright posture, which raised their risk of injury from falls.

Thus, the goal of the current investigation was to assess postural sway in individuals with type 2 diabetes mellitus, whether or not they also had polyneuropathy. The study's variable was postural sway in the

anteroposterior direction. This study had 40 individuals in total. Two groups of subjects were created: type 2 DM patients with polyneuropathy (Group A) and type 2 DM patients without polyneuropathy (Group B). Every group had twenty patients in it.

The mean and S.D for postural sway (AP direction in mm) of group A and B (EO) were 3.03±3.474 and 1.28±0.405, whereas the mean and S.D of postural sway of group A and B (EC) were 6.38±8.901 and 2.22±0.847. The mean differences were 1.76 and 4.16.

There was a significant difference between the postural sway (in AP direction) of Group A (DM type 2 with polyneuropathy) and Group B (DM type 2 without polyneuropathy). As the P values of group A and group B were 0.0307 (eyes open) and 0.0445 (eyes closed). In humans, visual information helps maintain postural stability. When one closes their eyes, their body sways more, and when they stand straight, their foot's center of pressure (CoP) shifts due to the altered optical flow in their peripheral vision.

Data obtained in our study for the postural sway indicates that the neuropathy group had greater range of sway (AP direction) for both eyes open and eyes closed conditions as compared to non-neuropathy group. Additionally, we observed that the neuropathy group showed larger sway with eyes closed than with eyes open. Above mentioned findings are in agreement with a previous study conducted by Dixit S, Maiya A, Shasthry BA, Kumaran DS, Guddattu V. in 2015.[14] In this study, the authors evaluated postural stability of 61 patients on posturography under 4 conditions. Postural stability measures showed an increase in mean values: velocity moment 20.4±1.3, 24.3±2.2, 42.3±20.7, 59±43.03; mediolateral displacement 0.21±0.10, 0.22±0.18, 0.03±0.11, 0.34±0.18; and anteroposterior displacement 0.39 ± 0.09, 0.45±0.12, 0.47±0.13, 0.51±0.20 from EO to EC, EOF, and ECF, respectively. In all situations, there was a significant difference ($P<0.05$) in the sway amplitude on hard and foam surfaces among the subjects with DPN. There was also a moderate connection ($r=0.43$) between MNSI and postural stability assessments and age.

The writers clarified it as one potential reason for the findings in the current study could be the impaired or diminished sensations in the patients with neuropathy which results in impaired balance which further worsens with occluded vision.[15]

Other reason could be weak intrinsic foot muscles which further leads to proprioceptive deficits since the patients recruited in current study had normal vestibular and visual functions.[16]

The results of the current investigation were in accordance with a study done by Yamamoto R, Kinoshita T, Momoki T, Arai T, Okamura A, Hirao K, Sekihara H in 2001.[17] who discovered that the subjects with DM type 2 without neuropathy had a postural sway (AP direction) of -0.25+1.27, subjects with DPN had -0.62+1.45, while the control group had -0.37+1.32. According to this study, individuals with type 2 diabetes who also have neuropathy exhibit increment in postural sway than those without the condition, both in terms of area and speed per second. It was shown that there is a strong correlation between postural instability and sensory neuropathy. When vestibular or visual signals are compromised or nonexistent, postural instability increases. Due to age-related physiological reductions in lower limb muscular strength and visual and vestibular function, standing balance deteriorates in older adults, which raises the risk of falls. These findings suggest that a patient's risk of falling is elevated when there is a notable decrease in balance linked to a cutaneous deficiency in the foot.

Another study found same results conducted by Palma FH, Antigual DU, Martínez SF, Monrroy MA, Gajardo RE. in 2013.[18] found a correlation between the DNE rating and the mean ratio of CoP in the DPN group, with a significance level of $p < 0.05$. Under the condition of closed eyes, significant

differences (p = 0.049) were seen, with a larger CoP ratio (0.548 cm vs. 0.442 cm) in the group with DPN. Under the open eyes condition, the DPN group exhibited a trend (p = 0.059) towards a higher CoP mean ratio (0.351 cm vs. 0.239 cm). Under the closed eyes condition, there was a significant association (p = 0.012) between the DNE rating and the CoP mean ratio (r = 0.751). Therefore, worsening balance would be associated with a larger presence of peripheral neuropathy-related characteristics, such as sensory degradation, a reduction in muscle strength, and a diminution of muscular reflexes.

Similar results were found in a study conducted by Katoulis EC, Ebdon-Parry M, Hollis S, Harrison AJ, Vileikyte L, Kulkarni J, Boulton AJ. In 1997.[16] who found that there was no discernible difference in body sway between the first group of patients with diabetic neuropathy and the two control groups. However, values were significantly higher (p, 0.05) among those who had previously experienced ulcers than in any other group in the aircraft and circumstances that were looked at. These data are suggestive of a link between inadequate body sway control and ulceration on the foot. Postural instability may raise the risk of and have clinical implications for Diabetic neuropathy sufferers may have mild trauma and ulceration.

In our study, both groups (Group A and Group B), have correlation between the postural sway (AP direction) in eyes open and eyes closed conditions was also significant at level 0.05 (two-tailed). A study shows similar results conducted by Anjos DM, Gomes LP, Sampaio LM, Correa JC, Oliveira CS. in 201079 found that the higher peak plantar pressure on the right hind foot was shown to be associated with higher displacement velocity (r = 0.2240) and larger radial displacement (Rd) (r = 0.2022). Increased radial displacement (RD) (r = 0.1972) and displacement velocity (P) (r = 0.5728) on the left hind foot were likewise correlated with increased peak plantar pressure. It was discovered that there was a positive correlation between BMI and plantar pressure in all areas of the foot, as well as between the amount of time from diagnosis and peak midfoot pressure (r = 0.3752) on the left and right sides.

LIMITATIONS:

The sample size of the study was small due to which generalization is difficult. Since the force platform cannot be transported everywhere, patients should be persuaded to visit the institution in order to receive their readings. It is impossible to regulate external factors. Because the current was a one-time investigation, no extended length of time was there to spend on observing the patients during the evaluation process. Lack of randomization may lead to selection bias. Absence of comparison with a control group of healthy individuals.

SCOPE FOR THE RESEARCH:

A greater number of samples should be used to conduct the investigation. Patients with Polyneuropathy may benefit from this study while planning their rehabilitation. Other parameters can be added in the study for better comparison such as diabetic subjects with different peripheral conditions may possibly be studied in the future. Different foot regions can be studied separately using the same parameters.

CLINICAL RELEVANCE OF STUDY

The study showed that there is a rise in postural sway (in AP direction in DM Type 2 patients with polyneuropathy. Therefore, in clinical practice postural sway should be assessed in all patients with polyneuropathy for early identification and appropriate intervention strategies should be used.

CONCLUSION

From the results of present study it is depicted that there is postural sway with reference to increase in deviation in Anteroposterior direction. Thus it can be concluded that DM Type 2 with polyneuropathy have increased postural sway as compared to the DM type 2 patients without polyneuropathy. Therefore, the results from the present study can be taken into consideration while assessing and treatment planning of patients with DM Type 2 with polyneuropathy.

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