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RESEARCH ARTICLE

TO STUDY AND COMPARE POSTURAL SWAY BY ROMBERG TEST IN DIABETIC AND NON-DIABETIC SUBJECTS

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ABSTRACT

BACKGROUND:

Diabetes is a silent disorder leading to disabling and fatal complications. The long-term complications of diabetes affect almost every system in the body. Balance impairment and postural instability is also observed in people having chronic diabetes which is a result of diabetic peripheral neuropathy, diabetic retinopathy, and vestibular dysfunctions.

OBJECTIVE:

The objective of this study is to find out the effect of chronic diabetes on postural sway by Romberg's test and thereby finding effects of diabetes on balance and stability.

METHOD:

60 participants, both male and female, between 40 to 60 years of age were included. The participants were divided into diabetic and non-diabetic groups (n=30). All the participants performed Romberg's test. Their postural sway was observed and subsequently Romberg's sign was noted. The procedure is repeated again two more times to find out average Romberg's sign.

RESULTS:

The data shows a significant difference in postural sway between diabetic and non-diabetic subjects. The Chi-square value computed for this comparison was 5.406, yielding a p-value of 0.020. The p-value was below the conventional significance threshold of 0.05, indicating a statistically significant association between diabetes status and the presence of postural sway. Diabetic individuals were significantly more likely to exhibit signs of impaired balance compared to non-diabetic individuals, as evidenced by the highly significant chi-square test result. This finding highlights the impact of diabetes on balance and stability.

CONCLUSION:

The study demonstrated that postural sway and instability was more common in diabetic subjects as compared to non-diabetic subjects between 40 to 60 years of age. Additionally, this study suggested that patients having diabetes should take measures to prevent postural instability, balance impairments and other complications of diabetes.

KEYWORDS

diabetes, proprioception, instability, postural sway, Romberg's test

INTRODUCTION

The most prevalent endocrine illness, diabetes mellitus, affects around 100 million individuals globally (6% of the total population) [1]. It is also anticipated that by 2040, there would be over 640 million adults worldwide who suffer from diabetes [2].

Diabetes mellitus (DM) is brought on by a disruption in insulin secretion and/or activity, which then results in hyperglycemia and ultimately impairs the metabolism of proteins, lipids, and carbohydrates [3]. Diabetes has a negative impact on an individual's functional abilities and quality of life, resulting in significant illness and premature death [4]. Diabetes-related microvascular and macrovascular problems frequently result in multiorgan anatomical, structural, and functional alterations in affected individuals [5]. Patients with type 1 or type 2 diabetes frequently experience diabetes complications, which also significantly increase morbidity and mortality. Microvascular and macrovascular chronic problems are the two main categories [6]. Microvascular problems comprise neuropathy, nephropathy, and retinopathy, whilst macrovascular issues encompass peripheral artery disease (PAD), cardiovascular disease, and stroke [7].

Peripheral neuropathy and retinopathy are common microvascular disorders that have been shown to increase postural sway and the risk of falls [8, 9]. Peripheral neuropathy patients have been observed to have postural instability and a raised sway area when standing motionless with their eyes closed [10,11,12]. Compared to those who are age-matched and acting as controls, people with Diabetic Peripheral Neuropathy (DPN) show a greater range of sway in the anterior-posterior and medial-lateral directions as well as a higher sway speed [13]. It has been demonstrated that individuals with DPN exhibit 66% more sway than healthy individuals of similar age when standing quietly with their eyes open [14].

When eyes are closed, postural stability in DPN patients decreases the most; this suggests that vision serves as a compensatory mechanism for sensory deficiencies [14]. Recurrent falls have also been linked to diminished vibration sensitivity and decreased pressure sensitivity, according to research [15]. This appears to be the result of a confluence of factors including reduced proprioception, vision, and potential vestibular system damage from prolonged hyperglycemia (a study on diabetic animals has shown that long-term hyperglycemia causes structural damage in the otolith organs of the vestibular system) [16].

Several studies show the association of diabetes with impaired balance and instability. Thus, the purpose of this study is to compare the postural stability between diabetic and non-diabetic subjects in middle adulthood (40 to 60 years) by performing Romberg's sign. The Romberg's sign is supposed to be observed while the examinee is standing, without shoes, with their feet placed together and crossed arms on the chest or down by the side [17]. In healthy persons, proprioceptive system (70%) vestibular system (20%) and visual system (10%) share the responsibility for keeping standing on a stable surface [18]. A positive Romberg sign is indicative of the loss of the ascending proprioceptive function of the lower limbs which may be observed in patients with peripheral neuropathy and proprioceptive changes as well in acute vestibular disorders [19].

MATERIAL AND METHODOLOGY

STUDY LOCATION AND DESIGN

This study was conducted in physiotherapy OPD, Integral University Lucknow and Old age Home, Vikas Nagar, Lucknow. The study design was cross sectional.

STUDY POPULATION

The study population selected using simple random sampling. Both males and females between ages 40 to 60 years who met with inclusion and exclusion criteria of study were selected. The population included the subjects who were either normal healthy individuals (never diagnosed with any type of diabetes) or diagnosed with type 2 diabetes for 5 years or more years. Also, the inclusion criteria were participants who were able to walk independently without any support, able to communicate, cooperate and follow the instructions and whose MMSE (Mini Mental State Examination) cognitive score is 25 or more (out of 30). Subjects were excluded from the study if they had any neurological impairment such as Parkinson's disease, Multiple sclerosis, history of stroke, surgery of lower extremity, fracture of lower limbs, subjects who were unstable, had any deformity, presence of any relevant visual / auditory impairment, presence of dizziness /vertigo, pregnant females. The participants were asked to sign a written informed consent. The sample size that was successfully collected consisted of 60 participants.

PROCEDURE

The subjects were categorized into two groups. Group A having diabetic subjects and group B having non-diabetic subjects. The demographic characteristics such as age, weight, height, BMI (body mass index) of the two groups were assessed at baseline before performing procedure. Similarly, MMSE was also assessed by the same physiotherapist supervising the test procedure. All the participants were asked to perform the two stage Romberg's test.

STAGE I In this stage the participants were asked to remove their shoes and stand with their feet together on a firm surface. Their arms down by their side with their eyes opened. The participants were asked to hold this position for 30 seconds. During this time, the therapist monitored the stability by seeing if participant was swaying or if he/she needed to move his/her arms or feet to maintain balance.

STAGE II In this stage the participants remained standing with their feet together. Their arms down by their side and their eyes closed. The participants held this position for 60 seconds. Their postural sway was observed and the time at which their postural sway was maximal was noted. The physiotherapist was standing near the subjects without touching them in order to prevent significant swaying or fall. The time at which participants started swaying and were unable to maintain the position is noted. The same procedure was repeated two more times to avoid any error occurring during procedure. Depending on whether postural sway was present or not participants were assigned either with positive or negative Romberg's sign. It was a single time study and it took approximately 30 minutes for the whole procedure and documentation.

STATISTICAL ANALYSIS

Data was analyzed using the software SPSS (version 16.0). Under descriptive statistics, qualitative variables were described in terms of frequency, percentage, and graphs such as pie chart, bar diagram etc. Normality of data was evaluated by plotting the numerical variable distinctly for each group or with the use of Shapiro-Wilk test. Quantitative variables were described in terms of mean and standard deviation. The Independent Samples t-test was used to compare the participants' characteristics between both diabetic and non- diabetic groups. The Chi-square test was used to test association of postural sway between Diabetic & Non-Diabetic subjects with their eyes opened/closed and hold position for 30/60 seconds. P value of less than 0.05 was considered as significant.

FIGURE 1: FLOW DIAGRAM OF THE STUDY

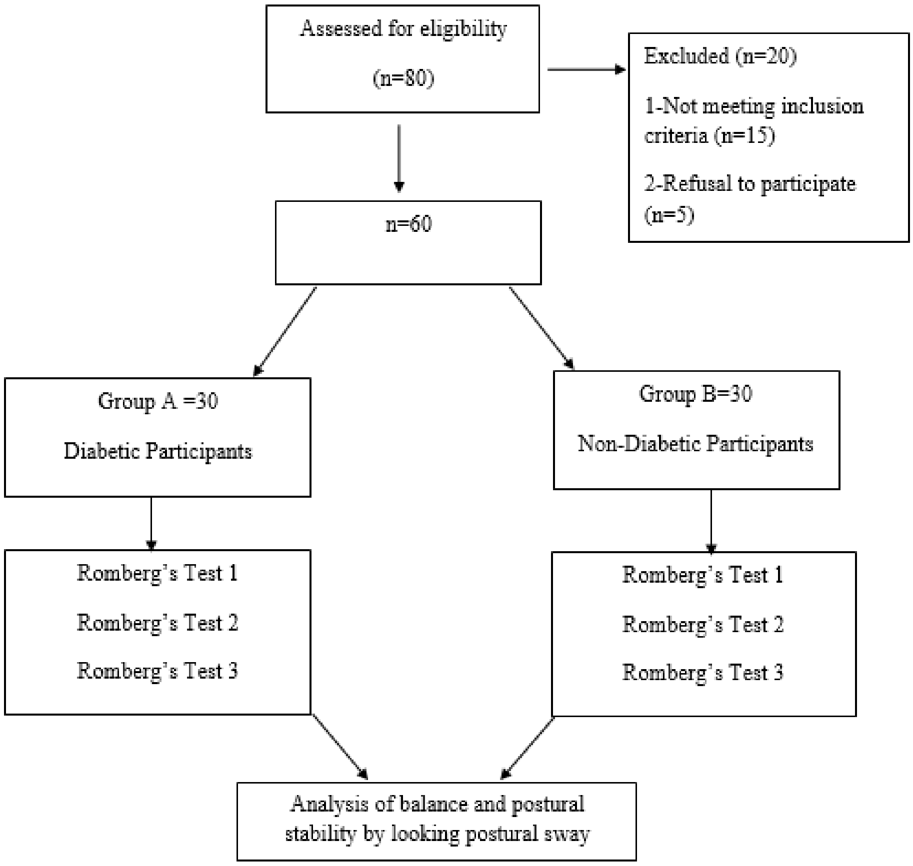


FIGURE 2: ROMBERG'S TEST WITH EYES OPEN

FIGURE 3: ROMBERG'S TEST WITH EYES CLOSED

TABLE 1: DESCRIPTIVE STATISTICS OF PARTICIPANTS' CHARACTERISTICS IN BOTH DIABETIC AND NON- DIABETIC GROUPS

	Group	N	Mean	Std. Deviation	Std. Error Mean
Age (Years)	Diabetic	30	49.63	5.846	1.067
	Non- Diabetic	30	49.43	5.935	1.084
Height (cm)	Diabetic	30	163.33	8.620	1.574
	Non- Diabetic	30	166.67	7.345	1.341
Weight (kg)	Diabetic	30	71.50	6.442	1.176
	Non- Diabetic	30	70.77	7.908	1.444
BMI (kg/m²)	Diabetic	30	26.93	3.181	0.581
	Non- Diabetic	30	25.55	3.109	0.568

Interpretation

Table 1 presents the descriptive statistics for age, height, weight, and BMI of participants in diabetic and non-diabetic groups, each with 30 participants.

The mean age of participants in the diabetic group is 49.63 years, with a standard deviation of 5.846 years and a standard error of 1.067 years. In comparison, the non-diabetic group has a slightly lower mean age of 49.43 years, with a standard deviation of 5.935 years and a standard error of 1.084 years. The closeness of the mean ages and their standard deviations suggests that both groups are quite similar in terms of age distribution.

For height, the diabetic group has a mean height of 163.33 cm, a standard deviation of 8.620 cm, and a standard error of 1.574 cm. The non-diabetic group has a higher mean height of 166.67 cm, with a standard deviation of 7.345 cm and a standard error of 1.341 cm. The non-diabetic group appears to be slightly taller on average, and the standard deviations indicate a comparable spread of height measurements within each group.

The mean weight of the diabetic group is 71.50 kg, with a standard deviation of 6.442 kg and a standard error of 1.176 kg. In contrast, the non-diabetic group has a mean weight of 70.77 kg, with a higher standard deviation of 7.908 kg and a standard error of 1.444 kg. While the mean weights are similar, the greater standard deviation in the non-diabetic group suggests more variability in weight among its participants compared to the diabetic group.

Regarding BMI, participants in the diabetic group have a higher mean BMI of 26.933 kg/m², with a standard deviation of 3.1818 kg/m² and a standard error of .5809 kg/m². The non-diabetic group has a lower mean BMI of 25.553 kg/m², with a standard deviation of 3.1089 kg/m² and a standard error of .5676 kg/m². The diabetic group, on average, has a higher BMI, though the standard deviations indicate similar variability in BMI measurements within both groups.

The descriptive statistics indicate that the diabetic and non-diabetic groups are closely matched in terms of age and weight. However, the non-diabetic group tends to be slightly taller, while the diabetic group has a higher average BMI. The standard deviations and standard errors suggest that the variability within each characteristic is relatively consistent across both groups, with slight differences observed in height and weight variability.

STAGE I: POSTURAL SWAY WITH EYES OPEN FOR 30 SECONDS

TABLE 2: ASSOCIATION OF POSTURAL SWAY BETWEEN DIABETIC & NON-DIABETIC SUBJECTS WITH THEIR EYES OPEN AND HOLD POSITION FOR 30 SECONDS.

READING		Study Subjects		Total	Chi Square	P value
		Diabetic	**Non-Diabetic**			
Postural Sway (With Eyes Open, 30 second)	Absent	24	28	52	2.308	0.129
		46.2%	53.8%	100.0%		
	Present	6	2	8		
		75.0%	25.0%	100.0%		
Total		30	30	60		
		50.0%	50.0%	100.0%		

Interpretation

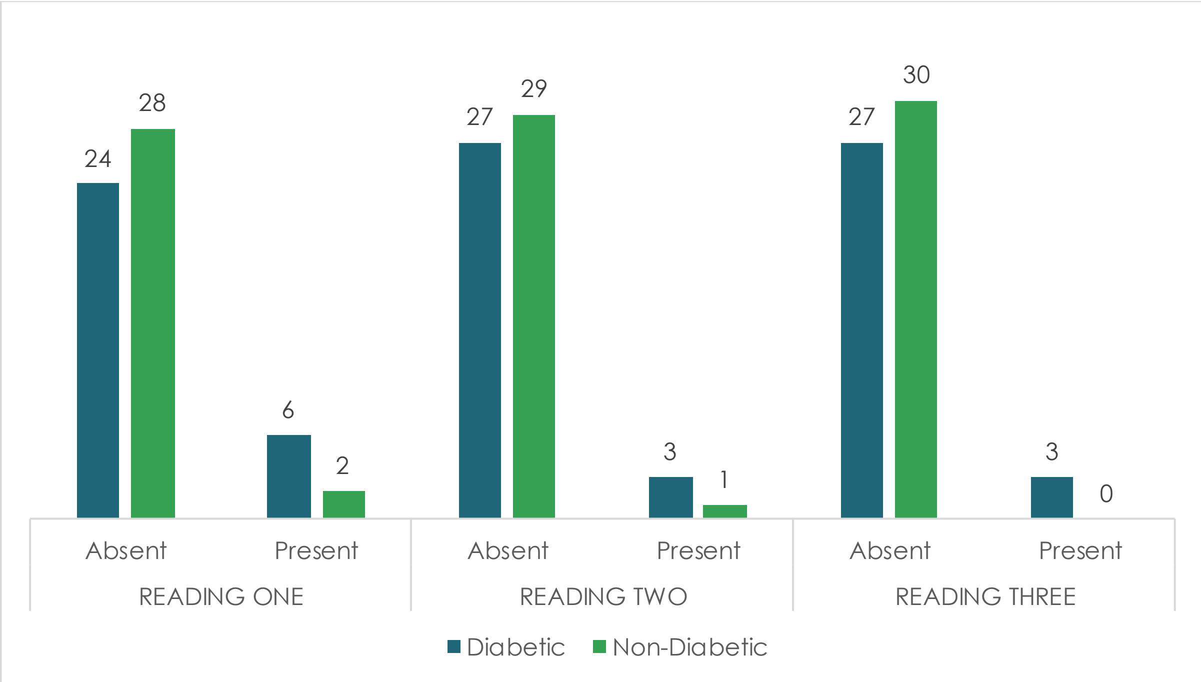
Table 2 provides an analysis of the association between postural sway and diabetic status among subjects holding a position with their eyes open for 30 seconds. The table categorizes the subjects into those with and without postural sway and presents the total counts, Chi-square value, and p-value to assess statistical significance.

Postural Sway (With Eyes Open, 30 seconds):

For the absence of postural sway, 24 out of 30 diabetic subjects (80%) did not exhibit sway, compared to 28 out of 30 non-diabetic subjects (93.3%). This results in a total of 52 subjects without postural sway, with the non-diabetic group slightly outperforming the diabetic group. Conversely, for the presence of postural sway, 6 out of 30 diabetic subjects (20%) showed sway, while only 2 out of 30 non-diabetic subjects (6.7%) experienced sway. This indicates that diabetic subjects show a higher incidence of postural sway compared to non-diabetic subjects when holding a position with eyes open for 30 seconds, highlighting a potential impact of diabetes on postural control.

The Chi-square value calculated is 2.308, with a p-value of 0.129. Since the p-value is greater than the standard significance threshold of 0.05, the results suggest that there is no statistically significant association between diabetic status and the presence of postural sway in this sample. This implies that the observed differences in postural sway between the diabetic and non-diabetic groups might be due to chance or other factors not accounted for in this study. Moreover, the findings suggest that there may be a trend towards an association, but it is not strong enough to be considered significant based on this sample size.

FIGURE 4: DISTRIBUTION OF POSTURAL SWAY IN THREE READINGS BETWEEN DIABETIC & NON-DIABETIC SUBJECTS WITH THEIR EYES OPEN AND HOLD POSITION FOR 30 SECONDS



STAGE II: POSTURAL SWAY WITH EYES CLOSED FOR 60 SECONDS

TABLE 3: ASSOCIATION OF POSTURAL SWAY BETWEEN DIABETIC & NON-DIABETIC SUBJECTS WITH THEIR EYES CLOSED AND HOLD POSITION FOR 60 SECONDS.

READING		Study Subjects		Total	Chi Square	P value
		Diabetic	Non-Diabetic			
Postural Sway (With Eyes Closed, 60 second)	Absent	10	19	29	5.406	0.020
		34.5%	65.5%	100.0%		
	Present	20	11	31		
		64.5%	35.5%	100.0%		
Total		30	30	60		
		50.0%	50.0%	100.0%		

Interpretation

Table 3 investigates the association between postural sway and diabetic status among subjects tasked with holding a position with their eyes closed for 60 seconds. The table provides a breakdown of participants who exhibited postural sway and those who did not, categorized by their diabetic or non-diabetic status, accompanied by chi-square values and p-values for statistical assessment.

Postural Sway (With Eyes Closed, 60 seconds):

In the diabetic group, 10 out of 30 subjects (34.5%) were able to maintain their posture without sway, while in the non-diabetic group, 19 out of 30 subjects (65.5%) showed no postural sway. Conversely, postural sway was observed in 20 out of 30 diabetic subjects (64.5%) compared to 11 out of 30 non-diabetic subjects (35.5%). This disparity underscores the higher prevalence of postural instability among diabetic individuals during the 60-second eyes-closed task.

The Chi-square value for this comparison is 5.406, yielding a p-value of 0.020. The p-value is below the conventional significance threshold of 0.05, indicating a statistically significant association between diabetes status and the presence of postural sway when visual input is removed. These findings highlight the critical impact of diabetes on postural stability. The statistical significance of the chi-square test (p = 0.020) reinforces the robustness of this association, suggesting that diabetes adversely affects proprioceptive feedback or neuromuscular coordination required for maintaining balance without visual cues.

FIGURE 5: DISTRIBUTION OF POSTURAL SWAY IN THREE READINGS BETWEEN DIABETIC & NON-DIABETIC SUBJECTS WITH THEIR EYES CLOSED AND HOLD POSITION FOR 60 SECONDS

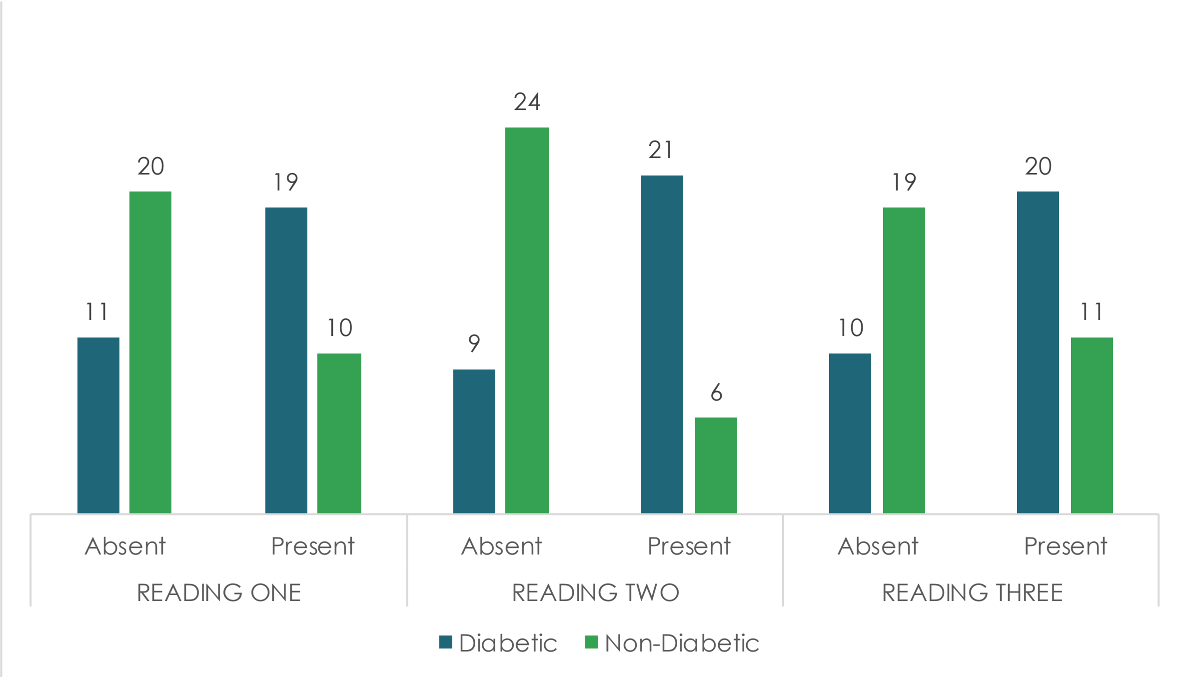


TABLE 4: ASSOCIATION BETWEEN STUDY SUBJECTS WITH ROMBERG'S TEST SIGN FOR BALANCE AND POSTURAL STABILITY BY OBSERVING POSTURAL SWAY

Romberg's Tests		Study Subjects		Total	Chi Square	P value
		Diabetic	Non-Diabetic			
Romberg's Sign	Negative	7	25	32	21.696	0.000
		21.9%	78.1%	100.0%		
	Positive	23	5	28		
		82.1%	17.9%	100.0%		
Total		30	30	60		
		50.0%	50.0%	100.0%		

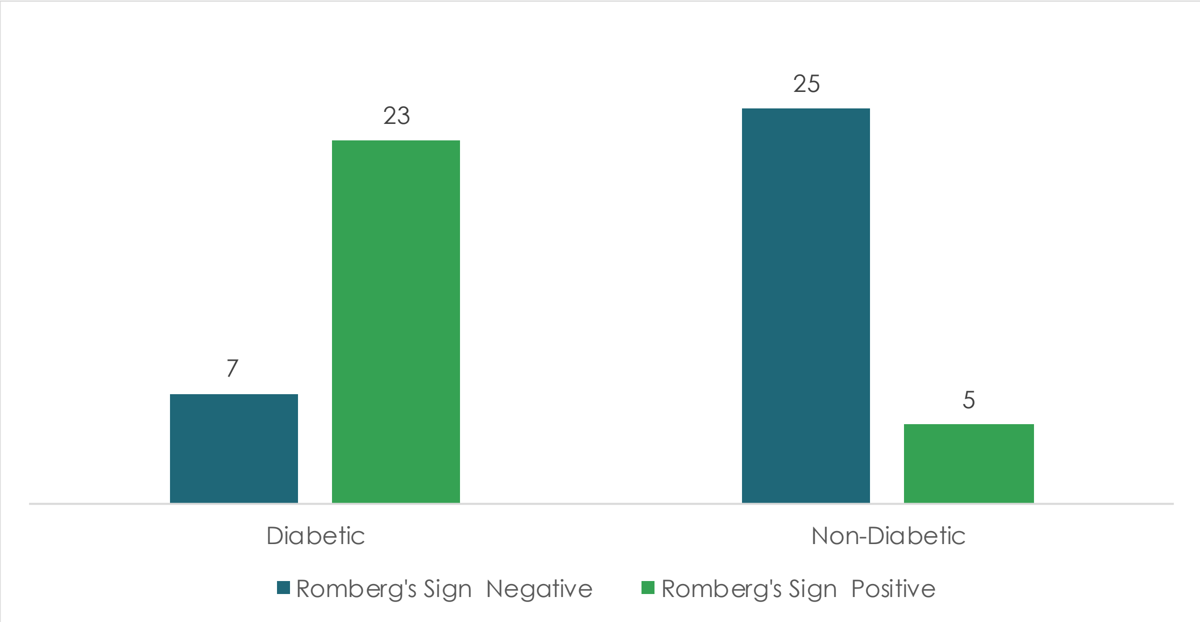
Interpretation

Table 4 examines the association between Romberg's test sign for balance and postural stability in diabetic and non-diabetic subjects. This table categorizes participants based on whether they tested negative or positive for the Romberg's sign, which reflects overall balance and proprioceptive function with eyes closed. It provides chi-square values and p-values to evaluate the statistical significance of the association.

Among diabetic subjects, 7 out of 30 (21.9%) tested negative for the Romberg's sign, indicating they were able to maintain balance with eyes closed. In contrast, 23 out of 30 (82.1%) diabetic subjects tested positive for the average Romberg's sign, suggesting impaired balance or postural instability. This distribution highlights a significant majority of diabetic individuals experiencing difficulty in maintaining balance without visual input, as indicated by the high prevalence of positive Romberg's test results. In the non-diabetic group, 25 out of 30 (78.1%) tested negative for the Romberg's sign, indicating better balance control, while 5 out of 30 (17.9%) tested positive. This demonstrates a smaller proportion of non-diabetic individuals showing signs of impaired balance compared to diabetic individuals.

The Chi-square value calculated for this comparison is 21.696, resulting in a p-value of 0.000. The p-value is well below the conventional significance threshold of 0.05, which suggest that diabetes significantly correlates with impaired overall balance and proprioceptive function particularly in conditions where visual cues are limited as assessed by the Romberg's test.

FIGURE 6: DISTRIBUTION OF ROMBERG'S TEST SIGN AMONG BOTH GROUPS



DISCUSSION

This cross-sectional study investigated the effects of diabetes on balance and postural stability and also compares the postural stability with non-diabetic individuals. The overall purpose of this study was to find how the complication of diabetes, especially diabetic neuropathy is affecting proprioception which contributes almost 70% in maintaining static balance [18].

Our findings indicated that the diabetic and non-diabetic groups were closely matched in terms of age and weight. However, the non-diabetic group tended to be slightly taller, whereas the diabetic group had a higher average BMI. Although obesity is a known risk factor for type 2 diabetes, the weight distributions between the two groups were broadly similar, suggesting that additional factors beyond BMI may contribute to postural instability in individuals with diabetes [20].

In Stage I of Romberg's test, where diabetic subjects show a higher incidence of postural sway compared to non-diabetic subjects when holding a position with eyes open for 30 seconds, the difference is not statistically significant. While this result suggests a possible trend toward an association, it is not sufficiently strong to be conclusive. Importantly, the discussion of these findings should not overstate the significance of group characteristics as study findings but rather focus on interpreting the relationship between diabetes and postural stability. A larger sample size or additional variables may be required to explore this trend further.

In Stage II of Romberg's test, findings demonstrated a significant association between diabetes and impaired postural control when visual input was removed. Diabetic subjects were significantly more likely to experience postural sway compared to non-diabetic subjects ($p = 0.020$). However, the interpretation of this association must also consider potential confounders, such as differences in proprioceptive function, neuromuscular coordination, or undiagnosed diabetic neuropathy within the study population. The statistical significance of the chi-square test reinforces the robustness of this association, suggesting that diabetes adversely affects proprioceptive feedback or neuromuscular coordination required for maintaining balance without visual cues.

This study also found a strong association between diabetes and impaired balance, as assessed by Romberg's test. However, the relationship between diabetes and postural instability should not be viewed in a one-dimensional manner, as multiple interacting factors contribute to balance impairments. While diabetes was significantly associated with poorer balance performance ($\chi^2 = 21.696$, $p = 0.000$), additional variables such as the duration of diabetes, presence of neuropathy, and levels of physical activity should be considered in future investigations to fully understand the mechanisms involved.

According to earlier research, falls are very common among older adults with type 2 diabetes; among those over 65, the annual incidence rate is 39%, and falls are more common in those with inadequate glycemic control [21]. Impaired balance is one of the most often recognized risk factors, despite the fact that falls are linked to a number of risk factors [22]. Diabetic individuals may experience sensory loss, decreased proprioception, and diminished spinal reflexes, all of which increase the risk of falling [23]. While this study provides valuable insights into balance impairments, future research should aim to explore how these factors interact over time and whether specific physiotherapeutic interventions can mitigate the risk of postural instability.

Romberg's test proved to be an effective tool for evaluating postural instability. The study also observed that diabetic individuals with a disease duration of more than five years exhibited greater postural instability, which is likely attributed to impaired proprioception. However, additional analysis incorporating neuropathy severity and functional assessments would strengthen this conclusion. This study highlights the importance of early intervention and awareness regarding postural instability in diabetic individuals, which may help in designing targeted rehabilitation programs.
In summary, while this study establishes a significant association between diabetes and postural instability, future research should take a more nuanced approach by integrating additional factors such as neuropathy severity, physical activity levels, and long-term glycemic control. Addressing these challenges through targeted interventions focused on proprioception and balance training could be crucial in reducing the risk of falls and improving the overall quality of life for diabetic individuals.

STUDY LIMITATIONS

The present studies have certain limitations. Firstly, the sample size used in the study was small, greater sample size in future may increase the efficiency of the study. Secondly this study was based on a single test for assessing postural stability, it could provide better findings if two or more reliable tests were used. Moreover, in this study few individuals who were non-diabetic were also observed having postural sway which might be due to presence of ataxia, vitamin B12 deficiency, copper deficiency, muscle weakness etc.

Future research can be conducted by giving various balance training interventions and then performing Romberg's test. In future this study can be conducted with advanced sensor-based tools or apps. Also, it is recommended to further explore the impact of age, diabetes type, and duration of the condition, while also considering non-diabetes-related factors that may influence balance.

CONCLUSION

The results of this study showed that diabetic patients suffer more often from balance disorders and postural instability than the rest of the population and are at higher risk of falling. This seems to be the consequence of a combination between impaired proprioception, vision, and damage to vestibular system. Furthermore, it is advisable to implement training initiatives for diabetes patients to improve their balance

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DECLARATION OF INTEREST:

The authors report no conflicts of interest.

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