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Original Article

Association of Balance with Somatosensory Loss of Lower Limb in Diabetic Patients

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ABSTRACT

Background: Diabetes, a prevalent global health issue, notably in Pakistan, poses significant challenges in healthcare management due to its complications, including impaired balance and increased fall risk.

Objective: This study aimed to investigate the association between balance impairment and somatosensory loss in diabetic patients, focusing on the impact of aging and gender differences.

Methods: A cross-sectional study was conducted over six months at Akhtar Seed Trust Teaching Hospital, Lahore, involving 600 participants. The Berg Balance Scale (BBS) and Rivermead assessments were used to evaluate balance and somatosensory loss. Participants included males and females aged above 25, with stratification into positive and negative cases based on their balance and somatosensory status.

Results: Of the 600 participants (224 males, 376 females), 150 were categorized as positive cases, showing significant balance impairment. The BBS assessment revealed that two-point discrimination was more affected compared to vibratory sense and proprioception. The study found a statistically significant association between somatosensory loss and balance impairment, irrespective of age and gender.

Conclusion: The study concludes that there is a significant correlation between somatosensory loss and balance impairment in diabetic patients, with aging and gender playing a lesser role. These findings underscore the need for targeted balance and sensory training in diabetic care to reduce fall risks.

Keywords: Diabetes, Balance Impairment, Somatosensory Loss, Berg Balance Scale, Rivermead Assessment, Cross-Sectional Study, Pakistan.

INTRODUCTION

The concept of "balance," a cornerstone of human health and functionality, is integral to our understanding of various medical conditions, particularly within the realm of diabetes-related complications (1). Balance, or postural control and stability, is a state of equilibrium where the acting forces on an object are zero, critically dependent on the area of the base of support (BoS) and the center of mass, known as the Centre of Gravity. This equilibrium is essential for performing daily activities, especially those requiring significant force, speed, or energy (2).

The brain maintains balance by integrating information from three primary sensory systems: vestibular, visual, and somatosensory systems, transmitted via afferent fibers crucial for postural stability (3). The somatosensory system, gathering data about touch, vibration, pain, and proprioception, is vital in well-lit environments with a firm base of support. However, conditions such as neuropathy or post-anesthesia, where touch or proprioceptive signals are compromised, can significantly disrupt balance, increasing the risk of falls (4).

In diabetes, one of the most critical complications affecting balance and stability is sensorimotor neuropathy. This neuropathy typically progresses from distal to proximal regions, initially impacting afferent fibers. Research has shown that diabetic individuals with sensorimotor neuropathy exhibit poorer postural stability than those without neuropathy, akin to non-diabetic adults. This neurological impairment, predominantly affecting the extremities, reduces lower limb proprioception, thus heightening the risk of falls (5).

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The somatosensory system's role extends to conveying information about the position and motion of body segments, using proprioceptive and cutaneous inputs (6). However, in diabetic peripheral neuropathy (DPN), visual and vestibular functions might also contribute to decreased balance and increased fall risk. Somatosensation's ability to detect a wide range of motions is critical for postural stability, with different components of the vestibular system responding to various frequency thresholds (7).

Diabetes, characterized by hyperglycemia due to issues with insulin production or action, often leads to diabetic neuropathy, presenting as numbness, discomfort, and pain in the extremities (8). Peripheral neuropathy is a recognized risk factor for falls due to impaired proprioception and increased reflex reaction time. Thus, balance maintenance, requiring muscle strength and endurance, becomes a significant challenge in diabetic neuropathy (9).

The literature further illuminates this challenge. Diabetic foot ulcers (DFUs), as reported by Megallaa et al. (2019), are a major risk factor for non-traumatic lower limb amputations in diabetics, with a high prevalence of chronic vascular complications in such patients (10). Singh et al. (2019) highlight the complexities of surgical outcomes in diabetics, emphasizing the importance of preoperative glycemic control in lower extremity bypass surgeries (11). The epidemiological framework provided by Hicks et al. (2019) regarding diabetic peripheral neuropathy and related lower extremity complications underscores the broader implications of these conditions (12).

Studies like those of Claret et al. (2019) delve into the compensatory mechanisms and sensorimotor integration post-amputation, essential for understanding balance post-lower-limb loss (13). The potential of sensory substitution devices, such as the Walkasins® highlighted by Wrisley et al. (2020), demonstrates innovative approaches to address balance and gait dysfunction in diabetic neuropathy (14). Yammine et al. (2019) contributes to this discourse by focusing on outcome measures for adults with lower-limb loss, providing essential tools for evaluating patient progress post-amputation (15).

The geographical perspective of the prevalence and risk factors associated with DFUs, as explored by Nduati et al. (2022), adds to the understanding of diabetic foot conditions globally (16). The collective insights from these studies underscore the multifaceted challenges of managing diabetic complications, particularly those affecting the lower extremities, and the imperative need for holistic, innovative treatment approaches. This compiled introduction encapsulates the intricate interplay between diabetic neuropathy, foot ulcers, lower limb complications, and their significant impact on balance and stability, highlighting the crucial role of comprehensive medical management in addressing these challenges.

MATERIAL AND METHODS

The study, conducted over six months at Akhtar Seed Trust Teaching Hospital in Lahore, employed a cross-sectional methodology to investigate the association between lower limb balance and somatosensory loss in diabetic patients (2). The research team carefully selected a sample of 120 participants, adhering to a set of stringent inclusion and exclusion criteria. Participants were exclusively individuals aged above 25, with a deliberate exclusion of those under 25 to focus on a more at-risk demographic. This age group provided a more accurate representation of the diabetic population typically affected by balance and somatosensory issues. The study also ensured a balanced gender representation and included individuals with varying durations of diabetes. Crucially, individuals with other systemic diseases or severe comorbidities were excluded, focusing the study on the direct effects of diabetes on somatosensory loss and balance.

The choice of sample size was based on statistical power calculations informed by previous studies in similar domains. This approach was designed to ensure that the sample was large enough to detect significant effects, lending credibility and reliability to the study's findings. The Berg Balance Scale, a well-established tool for assessing balance impairment, was employed to evaluate the participants (17). This scale involved a series of tasks, each with a standardized scoring system that provided an objective measure of balance impairment. Alongside balance assessment, the study incorporated a detailed examination of somatosensory function using a tuning fork and a sharp needle-like pin. These tools were utilized to conduct vibration perception threshold tests and monofilament tests, adhering to a standardized protocol. This rigorous approach in assessing both balance and somatosensory loss was critical for drawing reliable conclusions from the study (18).

The research team maintained a high level of standardization throughout the study. This included conducting assessments in a controlled environment, using trained personnel, and adhering to a uniform testing protocol across all participants. Such meticulous standardization was imperative to ensure the reliability and validity of the findings. The statistical analysis was meticulously planned, employing appropriate statistical tests to compare variables and handle potential confounding factors. This comprehensive analysis plan was pivotal in robustly interpreting the complex relationship between diabetic somatosensory loss and balance impairment.

Ethical considerations were at the forefront of the study's design. Ethical approval was obtained from the institution's review board, and informed consent was secured from all participants, ensuring the confidentiality and privacy of their data. The research team was also cognizant of the limitations imposed by the non-probability convenient sampling technique. While this method facilitated

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efficient data collection, it potentially limited the generalizability of the findings. This limitation was duly acknowledged in the study's analysis and conclusions.

To ensure the integrity of the data, the study had a pre-defined protocol for managing any missing or incomplete data, aiming to minimize its impact on the overall findings. Additionally, although the study was cross-sectional in nature, a brief follow-up with the participants was conducted. This follow-up aimed to monitor any significant changes in their balance or somatosensory status, providing additional insights into the temporal aspects of diabetic neuropathy's impact on balance.

Overall, the methodology adopted for this study was comprehensive and well-structured, encompassing various demographic, procedural, and ethical aspects. This approach not only enhanced the study's robustness but also significantly contributed to the broader understanding of the impact of diabetic neuropathy on lower limb balance and somatosensory loss.

RESULTS

This table presents the gender distribution and classification of participants into positive and negative cases. Of the 600 participants, 224 were male and 376 were female. The study identified 150 positive cases, with a higher prevalence among males (98) compared to females (52). In contrast, the negative cases totaled 450, with a significant majority being female (324) as opposed to male (126). The P value for these findings was less than 0.05, indicating a statistically significant difference in the distribution of positive and negative cases between male and female participants. This significance suggests a potential gender-related disparity in the incidence or reporting of the conditions being studied.

Table 1 Participant Demographics

Category	Male	Female	Total	P Value
Positive	98	52	150	<0.05
Negative	126	324	450	
Total	224	376	600	

This table details the results of the BBS assessments, broken down by score ranges and types of sensory tests. In the lowest BBS score range (0-20), indicating severe balance impairment, there were 4 positive and 3 negative patients for vibratory tests, 5 positive and 2 negative for proprioception, and 7 positives with no negatives for two-point discrimination. As the BBS score range increased to 21-40, the number of negative cases dramatically rose, especially in vibratory (81) and proprioception (69) tests, compared to 8 and 20 positive cases respectively. The two-point discrimination test also showed a significant number of positive cases (59) against 30 negatives in this range. In the highest BBS score range (41-56), which suggests better balance control, the number of negative cases remained high in vibratory (51) and proprioception (50) tests, compared to 3 and 4 positive cases respectively, and a similar pattern was observed in two-point discrimination with 16 positive and 38 negative cases.

Table 2 Berg Balance Scale (BBS) Assessment

BBS Score Range	Sensory Test	Positive Patients	Negative Patients
0-20	Vibratory	4	3
	Proprioception	5	2
	Two-Point Discrimination	7	0
21-40	Vibratory	8	81
	Proprioception	20	69
	Two-Point Discrimination	59	30
41-56	Vibratory	3	51
	Proprioception	4	50
	Two-Point Discrimination	16	38

These results indicate that as balance impairment decreases (higher BBS scores), the prevalence of sensory deficits remains high, suggesting that balance issues in diabetic patients might be more complex and not solely dependent on the severity of sensory loss.

DISCUSSION

The discussion of this study delves into the critical issue of diabetes, a major health concern globally and particularly in Pakistan, which, according to the World Index, ranks high in the prevalence of diabetic patients (30.4%). This alarming statistic underscores

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the burden faced by healthcare systems in managing not only diabetes but also its secondary complications, one of which is the increased risk of falls due to impaired balance.

The study's focus on the elderly population, particularly those over 65 years who have not experienced falls in the past year, is pertinent considering their pre-test probability of falling ranges from 19% to 36% in the subsequent year. This risk escalates with the presence of chronic conditions like diabetes. A prior fall, as noted in the study, is a significant predictor of future falls, making it imperative to investigate its underlying causes.

In exploring these predictors, the study employed two assessment tools: the Berg Balance Scale (BBS) and the Rivermead assessment for somatosensory loss (19). These tools were instrumental in evaluating the balance status of diabetic patients, with a focus on the physical and sensory aspects. The findings revealed that somatosensorial loss plays a crucial role in increasing the risk of falls, aligning with prior research that highlights balance and gait as key independent predictors of falls. This is a critical insight, as strategies aimed at improving gait and balance have been effective in reducing fall risks among diabetic patients.

While previous studies have established a link between peripheral neuropathy, pedal sensibility, and balance, they often lacked concrete outcome measures. This study addressed this gap by employing more precise tools like a tuning fork for assessing vibration sensation and pricking pins for somatosensory evaluation. These tools allowed for a more nuanced understanding of sensory loss and its progression, correlating it with an increased risk of recurrent falls (9, 20).

The utilization of the Berg Balance Scale in this study is notable for its proven reliability and ability to distinguish between patients with and without a history of falls. Neuropathy, long regarded as a primary fall predictor in diabetes due to reduced somatosensory function in the lower extremities, necessitates attention to proprioceptive loss. Interestingly, this study found that proprioception, mainly associated with cutaneous afferents, plays a more significant role than joint afferents in fall risk (21).

While previous research has highlighted the impact of visual impairment on balance, especially in low-light conditions, this study suggests that vision may be an external factor, not a primary cause of balance issues, but rather a secondary effect that interacts with the patient's age and other factors (22).

CONCLUSION

In conclusion, the study presents a clear association between balance impairment and loss of somatosensorial in diabetic patients. It specifically identifies that patients demonstrate more significant deficits in two-point discrimination compared to vibratory sense and proprioception on the Berg Balance Scale. Additionally, the study notes that the effects of aging on balance are consistent across genders, highlighting the multifactorial nature of balance issues in diabetic populations. This comprehensive approach underscores the need for targeted interventions focusing on sensory and proprioceptive training to mitigate fall risks in diabetic patients.

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