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Balance and Level of Confidence in Type-2 Diabetes Mellitus without Diabetic Neuropathy among Middle-aged Adults

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ABSTRACT

Background: Type-2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and hyperglycemia that can impair balance, even without neuropathy, due to changes in proprioception and muscle performance. Altered sensory processing and reduced nerve function can affect proprioception, while decreased strength and coordination deficits weaken muscle performance, making balance control more difficult.
Aims and objectives: To evaluate Balance and Level of Confidence in Type-2 Diabetes Mellitus without Diabetic Neuropathy among Middle-Aged Adults.
Method: 61 middle-aged adults (age 45-60) with T2DM for more than 5 years, no neuropathy, and a 6/6 score on the Ipswich Touch Test were included. Balance was assessed using the Single Leg Stance (SLS) test (both eyes open and closed) and level of confidence by Activities-specific Balance Confidence (ABC) scale.
Result: The SLS-EO (eyes open) mean score was 8.69 ± 5.10 seconds, indicating moderate balance ability. However, when visual input was removed (SLS-EC, eyes closed), the mean score dropped to 2.97 ± 5.29 seconds, reflecting a greater impairment in balance without visual support. Despite this, participants reported high level of confidence in their balance, with an ABC score of 92.8 ± 8.35.
Conclusion: Middle-aged adults with T2DM without neuropathy showed moderate balance, with significantly greater impairment when visual input was removed, suggesting proprioceptive involvement. Despite these balance challenges, participants demonstrated high confidence in their balance, indicating a discrepancy between perceived and actual balance performance.

Keywords: Type-2 DM, Balance, SLS Test, ABC Scale, Without Diabetic Neuropathy, Diabetes Mellitus

INTRODUCTION

Diabetes Mellitus (DM) is a condition characterized by elevated blood glucose levels & disruptions in the body's ability to metabolize carbohydrates, proteins & fats, often due to a lack of insulin or its ineffective action. [1]

Diagnosis of DM is confirmed when fasting blood glucose exceeds 126 mg/dL, when blood glucose is over 200 mg/dL after a 2-hour oral glucose tolerance test, or when it

is greater than 200 mg/dL at any random time. The normal range is less than 100 mg/dL for fasting levels and under 140 mg/dL after 2 hours. [1]

Classification of DM is determined by its underlying cause: Type 1 diabetes results from the destruction of pancreatic beta cells that produce insulin, while Type 2 diabetes is due to insulin resistance and insufficient insulin production. Over 95% of diabetes cases are classified as Type 2. [1]

While the primary focus of T2DM management often centers around glycaemic control, the disease can lead to various complications that significantly affect an individual's overall quality of life. Among these, balance issues are a common complication of DM, while many studies link balance problems to diabetic patients with neuropathy, which results from nerve damage and impairs sensory feedback, especially from the lower limbs, there is less research indicating that balance can also be affected in individuals with T2DM who do not have neuropathy. [2]

Balance problems in individuals with diabetes are often associated with microvascular damage caused by prolonged high blood sugar. This damage may interfere with sensory nerves that transmit proprioceptive signals to the brain, disrupting the body's sense of position and movement, which in turn affects balance. Balance control is influenced by several factors including vision, proprioception (the sense of body position), vestibular function (inner ear balance), cerebellar function (coordination), & the muscle strength of the lower limbs. [2]

In individuals with diabetes, balance may be impaired even without neuropathy, as microvascular damage due to high blood glucose can still affect proprioception, impairing the sensory input necessary for maintaining balance and stability, as well as the strength of lower extremity muscles. [2]

Peripheral neuropathy in diabetes is not the only factor that can impair balance. Microvascular changes in the body, even in the absence of neuropathy, can also disrupt the sensory feedback necessary for balance control, increasing the risk of falls. [3]

Three sensory systems contribute to balance control: the somatosensory system, the visual system, and the vestibular system. Each provides critical information to the brain for maintaining stability and orientation. [4]

The somatosensory system provides essential information about the position and movement of the body's segments in relation to one another and the support surface. It does this through proprioceptive inputs (such as joint position and kinesthesia) and cutaneous inputs (including touch and vibration sensitivity). Somatosensory system is the largest and most rapidly conducting sensory fibers which include the 1a afferents from muscle spindles, the 1b afferents from Golgi tendon organs, and cutaneous mechanoreceptors. The visual system provides information about the surrounding environment and helps the brain determine body orientation within that environment. The vestibular system, located in the inner ear, provides feedback on head position and spatial orientation, allowing the brain to maintain balance. [4]

Damage or decline in one or more of these sensory systems reduces the sensory information that the central nervous system relies on. This loss of backup information can significantly affect balance and increase the risk of falling. [4]

Balance impairment in individuals with diabetic neuropathy is primarily attributed to nerve damage, particularly in the lower limbs. This damage disrupts the ability to perceive the position of the body in space (proprioception), affecting the brain's ability to coordinate muscle movements and maintain postural control. As a result, individuals with diabetic neuropathy may exhibit delayed reactions to shifts in their body position and reduced ability to make quick adjustments to prevent falls.

In contrast, individuals with Type-2 Diabetes Mellitus (T2DM) who do not have neuropathy still experience balance

challenges, but the mechanisms behind these difficulties differ. In individuals without neuropathy, balance problems are more likely to stem from muscular and proprioceptive impairments, rather than direct sensory loss. These individuals may have reduced muscle strength and coordination, especially in the lower limbs, which makes it more difficult to adjust to changes in posture or maintain stability. Additionally, muscle function in T2DM is often impaired due to poor glucose regulation, which leads to poor energy production and muscle performance, further contributing to balance issues. As a result, balance in individuals without neuropathy is likely to be influenced by a combination of reduced muscle strength, compromised proprioception, and the overall metabolic disruptions caused by T2DM.

Muscle spindles detect changes in muscle length, while Golgi tendon organs sense muscle tension. Cutaneous mechanoreceptors are responsible for detecting sensations such as vibration and pressure. The muscular system in Type 2 diabetes is affected by impaired glucose regulation, which negatively impacts both mechanical and metabolic muscle functions. Muscles rely on oxidative phosphorylation for energy, and the dysfunction caused by insulin resistance leads to impaired energy production and muscle function. Further muscle metabolic dysfunction is linked to reduced mitochondrial response to insulin, which affects muscle energy utilization and leads to poorer muscle performance due to insulin resistance and decreased substrate usage. [5]

Musculoskeletal complications in diabetes, such as limited joint range of motion and weakened muscle strength, are among the most common long-term effects of the disease. These conditions contribute to functional decline and increased difficulty in maintaining balance. Metabolic changes in diabetes, such as damage to small blood vessels & nerve degeneration, along with collagen accumulation in skin and periarticular tissues, lead to changes in connective tissue and muscle structure. These changes negatively impact muscular function. [5]

Collectively, these complications may result in significant decreases in overall muscle strength and function, particularly in adults with Type 2 diabetes, contributing to greater difficulty in maintaining balance and increased fall risk. [4]

Diabetes Mellitus is a public health problem and has many complications such as decreased motor and functional performance of the lower limbs which can interfere with maintaining balance and consequently increase the risk of falls and difficulties in carrying out activities of daily living. Also, assessing balance confidence is important in this study as it helps understand how individuals perceive their ability to maintain balance and prevent falls. Even with physical impairments, people with Type 2 Diabetes Mellitus (T2DM) may feel confident in their balance, which can influence their risk of falls and participation in physical activities. By evaluating balance confidence through the ABC scale, this study aims to provide a comprehensive view of balance performance and its impact on daily activities and quality of life.

While much research has focused on balance impairment in individuals with diabetic neuropathy, there is a gap in exploring balance issues and level of confidence in diabetic patients without neuropathy. This study is an attempt to evaluate balance and level of confidence in Type-2 Diabetes Mellitus without Diabetic Neuropathy among Middle-Aged Adults.

MATERIALS & METHODS

The data for this observational study was collected from various residential areas in Ahmedabad, focusing on middle-aged adults with Type-2 Diabetes Mellitus. 61 middle-aged adults (age 45-60) with T2DM for more than 5 years, no neuropathy, and a 6/6 score on the Ipswich Touch Test were included.

The study will utilize a convenient sampling method with a sample size of 61

participants, and the duration of the study was 3 months. Data collection tools included a consent form, an assessment form, pen and paper, a stopwatch, and score sheets for the Single Leg Stance Test (SLS Test) and Activities-specific Balance Confidence (ABC) scale.

INCLUSION CRITERIA:

- Type-2 DM Patients without Neuropathy
- Middle-aged adults: 45 to 60 years
- Having Type-2 DM for more than 5 years
- Ipswich Touch Test: 6/6

EXCLUSION CRITERIA:

- Clinically diagnosed Diabetic neuropathy.
- Cardiovascular conditions (coronary artery disease, heart valve disease, angina, cardiomyopathies, peripheral artery disease).
- Neurological conditions (Parkinson's disease, Stroke, Cerebellar ataxia).
- Rheumatological and musculoskeletal conditions (Osteoarthritis, sprains, strains), surgical problem in lower limb, severe retinopathy, severe nephropathy, vertigo, presence of vestibulopathies that could interfere with activities of daily living.
- Inability to walk independently with or without an assistive device.
- Uncontrolled hypertension, hypotension or blood glucose level.

Outcome Measures:

Single Leg Stance Test (SLS Test): The Single Limb Stance (SLS) test is an outcome measure designed to assess static balance and the ability of the subject to stand on a pathological or sound limb. Reliability: Excellent relative reliability for SLST (ICC = 0.86). The subject begins in quiet standing with hands on the hips. The subject lifts one leg off the ground and stands unassisted with eyes open (SLS-EO) and then with eyes closed (SLS-EC). Time starts when the foot is lifted off the ground. Time stops when the lifted foot either makes contact with the ground, makes contact with the stance limb, when the stance foot moves laterally on the floor, or when the hands leave the hips. The subject completes three trials on the leg being tested. The average of the three times is recorded. The leg being tested is the leg that remains in contact with the ground. The stance foot must remain flat on the floor at all times. Scoring is as follows: Low Risk >20s, Moderate Risk 5-20s and High Risk <5s. [6]

Activities-specific Balance Confidence (ABC) scale: Activities-specific balance confidence (ABC) scale is a structured questionnaire that measures an individual's confidence during ambulatory activities without falling or experiencing a sense of unsteadiness. Reliability: Excellent overall test-retest reliability (ICC=0.85). It is a 16-item questionnaire where patients' rate their confidence while doing activities. Scoring from 0-100 (0 is no confidence and 100 is full confidence). Lower than 50 %: low level of physical functioning, 50-80 %: moderate level of physical functioning and above 80 %: high level of physical functioning. [7, 8, 9]

PROCEDURE

After obtaining ethical clearance from the institute, the patients were selected based on the inclusion and exclusion criteria by the convenient sampling method. Entire procedure was explained to the patient and consent was taken for the same. Balance was assessed using the Single Leg Stance (SLS) test with both eyes open (SLS-EO) and eyes closed (SLS-EC), and balance confidence was measured using the Activities-specific Balance Confidence (ABC) scale.

RESULT

The results of this study revealed significant insights into the balance abilities and confidence levels of middle-aged adults with Type-2 Diabetes Mellitus (T2DM) without diabetic neuropathy. On the Single Leg Stance (SLS) test, the mean score with eyes open (SLS-EO) was 8.69±5.10

seconds, indicating moderate balance performance. This suggests that participants could maintain balance reasonably well when visual input was available.

However, when the visual input was removed (SLS-EC), the mean score significantly decreased to 2.97 ± 5.29 seconds, reflecting a notable decline in balance performance. This marked reduction in balance performance without visual support implies that proprioception, the body's ability to sense its position in space, plays a crucial role in balance control for individuals with T2DM. (Table 1) (Figure 1 & 2)

Despite these balance impairments, participants reported a high level of confidence in their ability to maintain balance. The average score on the Activities-specific Balance Confidence (ABC) scale was 92.8 ± 8.35, which falls into the "high confidence" category, suggesting that participants felt secure performing daily activities without a significant fear of falling. This discrepancy between actual balance performance and perceived balance confidence points to a potential overestimation of balance abilities among individuals with T2DM, which may increase their risk of falls, as they may not recognize the true extent of their balance impairments.

However, significant variability in both balance performance and confidence suggests that balance may still be subtly affected by diabetes, even in the absence of neuropathy.

Outcome Measures	Mean	SD (±)
SLS EO	8.69s	5.10
SLS EC	2.97s	5.29
ABC	92.8%	8.35

Table 1

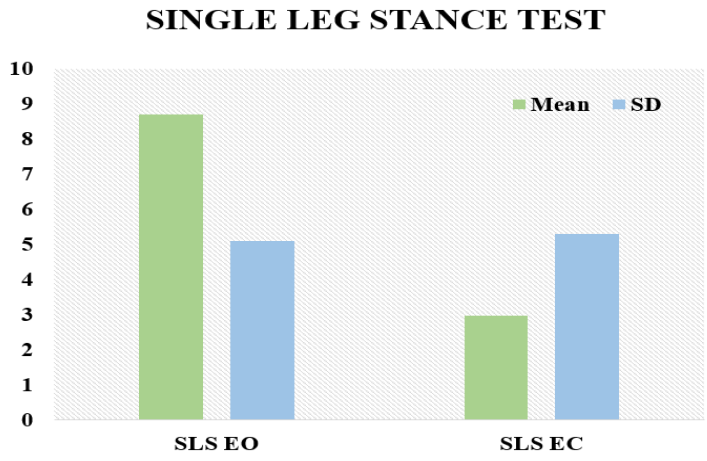

Figure 1

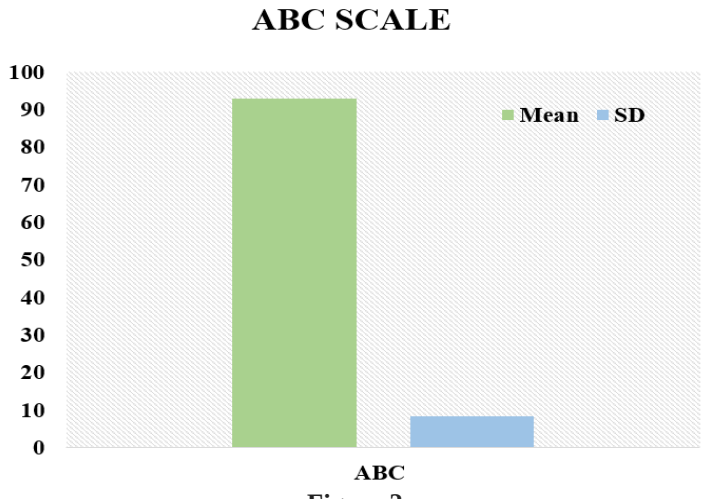

Figure 2

DISCUSSION

The results of this study indicate that middle-aged adults with Type-2 Diabetes Mellitus (T2DM), without diabetic neuropathy, exhibit moderate balance impairments. The Single Leg Stance (SLS) test revealed a mean score of 8.69 ± 5.10 seconds with eyes open, indicating moderate balance ability. However, when visual input was removed (SLS-EC), balance performance significantly declined to 2.97 ± 5.29 seconds, suggesting that proprioception plays a key role in balance control for individuals with T2DM, even without neuropathy. The high confidence levels reported on the Activities-specific Balance Confidence (ABC) scale (92.8 ± 8.35) suggest that, despite the moderate balance impairments observed in the SLS test, these individuals felt capable in performing daily activities without a significant fear of falling.

This confidence, however, does not fully align with their actual balance performance, suggesting that perceived confidence in balance may not always correlate with objective balance ability.

Three sensory systems (somatosensory, visual and vestibular) contribute sensory information required for balance control. The somatosensory system provides information about the position and motion of body's segments in relation to each other and the support surface by using proprioceptive (joint position/kinesthesia) and cutaneous (touch and vibration sensitivity) inputs. The visual system provides information about the environment and body orientation. The vestibular system provides information about head position and spatial orientation.[10]

Type 2 diabetes-related impaired glucose regulation is known to affect mechanical and metabolic muscle function due to the dependency on oxidative phosphorylation for energy production. Specifically, complications of reduced phosphorylation and glucose transport, along with increased fatty-acid metabolism can result in abnormal accumulation of free fatty acids and triglycerides in skeletal muscle cells. Further impaired metabolic muscle function has been linked to reduced muscle mitochondrial response to insulin due to insulin resistance and reduced substrate utilization. Collectively, these complications can result in significant declines in overall muscle strength and function in adults with type 2 diabetes. [11]

These findings imply that, even in the absence of neuropathy, T2DM can still subtly affect balance due to impairments in proprioception and sensory processing. This could be due to metabolic changes affecting the muscles, joints, or other sensory systems that contribute to balance control. Therefore, despite feeling confident, individuals with T2DM may be at increased risk of falls and should be monitored for balance-related impairments.

Clinicians should assess balance even in individuals with T2DM who do not have neuropathy, as proprioceptive impairments could still pose a fall risk. Early interventions to address balance issues could be beneficial.

Limitations of this study is that the study only included middle-aged adults, which may not represent the broader diabetic population, as younger or older individuals may have different health conditions and responses to treatments, secondly, the sample was drawn from a single geographical area, meaning the findings may not apply to diabetic populations in other regions with different lifestyles, healthcare systems, or environmental conditions.

Future research should include age-matched controls, gender specific study, explore fall prevention strategies, proprioception-based interventions.

CONCLUSION

The study concluded that middle-aged adults with Type-2 diabetes mellitus, without neuropathy, had high balance confidence, but their actual balance performance varied. Participants showed better stability with eyes open (SLS-EO)

than with eyes closed (SLS-EC). Despite high confidence, balance ability was inconsistent, suggesting that diabetes may still subtly affect balance, even without neuropathy.

Even without diabetic neuropathy, adults experienced balance impairments, particularly when visual input is removed. Despite these impairments, participants reported high confidence in their balance, which does not always align with their actual balance performance.

This suggests that individuals with T2DM may overestimate their balance abilities, potentially increasing their risk of falls. Healthcare professionals should monitor balance in individuals with T2DM & recommend interventions to address proprioceptive & muscle performance issues, even in the absence of neuropathy. Future studies should further explore this balance challenges & develop tailored interventions to reduce fall risk in this population.

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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