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Original Research Article

ASSESSMENT OF VESTIBULAR FUNCTION AND BALANCE IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is associated with neurological and sensory complications that may adversely affect postural control. Vestibular dysfunction may be an under-recognised contributor to dizziness, imbalance and falls in individuals with diabetes. Early identification of vestibular impairment may support appropriate clinical management and rehabilitation.

Objective: To assess vestibular function and balance in patients with T2DM and to determine their association with duration of diabetes, glycaemic control and related clinical factors.

Materials and Methods: A hospital-based observational cross-sectional study was conducted among 56 patients diagnosed with T2DM. Demographic and clinical information, including duration of diabetes and glycated haemoglobin (HbA1c), was recorded. Vestibular function was assessed using clinical vestibular examination, Video Head Impulse Test and Vestibular Evoked Myogenic Potentials. Balance was evaluated using standardised clinical balance measures. The association between vestibular dysfunction and diabetes-related clinical variables was analysed using appropriate statistical methods, with statistical significance considered at $p<0.05$.

Results: Vestibular abnormalities were identified in a considerable proportion of participants, with abnormalities observed in vHIT, cVEMP and oVEMP assessments. Balance impairment was also observed in approximately one-third of participants. Vestibular dysfunction was more frequently noted among individuals with longer diabetes duration, HbA1c levels above 7%, diabetic peripheral neuropathy, and symptoms of dizziness or unsteadiness.

Conclusion: Vestibular dysfunction and balance impairment were common among patients with T2DM. Vestibular assessment may therefore be considered in diabetic patients presenting with dizziness, imbalance or increased fall risk.

Keywords: Type 2 Diabetes Mellitus, Vestibular Dysfunction, Vestibular Function, Balance, Vestibulo-Ocular Reflex, Vestibular Evoked Myogenic Potentials, Dizziness, Postural Stability, Diabetic Neuropathy, Fall Risk.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterised by persistent hyperglycaemia and is associated with progressive vascular, neurological and sensory complications. Although diabetic peripheral neuropathy and retinopathy are well-recognised causes of impaired mobility and falls, the vestibular system has received comparatively less attention. The vestibular apparatus plays an important role in maintaining posture, spatial orientation and gaze stability by integrating information from the semicircular canals and otolith organs with visual and somatosensory inputs. Therefore, impairment of vestibular function may further compromise balance in individuals with T2DM, particularly when other diabetic complications are present.[1,2] The possible

association between diabetes and vestibular dysfunction has been attributed to chronic metabolic and microvascular changes. Prolonged hyperglycaemia may produce oxidative stress, microangiopathy and neural degeneration, potentially affecting the peripheral vestibular end organs and their neural pathways. However, the exact mechanisms and the specific vestibular structures affected are not yet clearly established.[2,3] A systematic review from India also highlighted that the evidence regarding vestibular involvement in T2DM remains inconsistent, with different studies reporting variable findings depending on the vestibular tests employed.[4] Objective vestibular investigations have nevertheless provided evidence of subclinical abnormalities in patients with T2DM. Ward et al. reported impaired semicircular canal function in 70% and otolith organ impairment in 50% of adults with long-standing T2DM when assessed using dynamic visual acuity and vestibular evoked myogenic potentials (VEMPs).[5] Similarly, Konukseven et al. observed prolonged ocular and cervical VEMP latencies in patients with T2DM, with significant associations between VEMP abnormalities and glycated haemoglobin and fasting blood glucose levels.[6] Kalkan et al. found reduced cervical and ocular VEMP amplitudes in patients with T2DM, including those with diabetic polyneuropathy, although video head impulse test findings did not differ significantly from controls.[7] These findings suggest that vestibular involvement may occur even in the absence of prominent vestibular symptoms. Clinical evidence also indicates that vestibular dysfunction may contribute to impaired balance and increased fall risk. Li et al. reported vestibular dysfunction in 56.7% of patients with T2DM compared with 27.9% of controls, and the dysfunction was associated with disease duration and HbA1c levels.[8] Patients with T2DM who experience vertigo, dizziness or unsteadiness have also demonstrated impaired postural stability, increased centre-of-pressure displacement and greater sway during conditions involving visual and vestibular-visual interaction.[9] More recently, Komalasari et al. demonstrated that T2DM patients with vestibular dysfunction had poorer static and dynamic balance, reduced falls-efficacy, lower social participation and poorer quality of life compared with those without vestibular dysfunction.[10] Despite these observations, vestibular dysfunction is not routinely evaluated as part of the assessment of individuals with T2DM. Recent literature emphasises that the likelihood of vestibular and balance impairment may increase with longer disease duration and poorer glycaemic control, supporting the need for greater clinical awareness.[1] Comprehensive assessment using appropriate vestibular and balance measures may help identify otherwise unrecognised dysfunction and distinguish vestibular impairment from balance deficits caused by peripheral neuropathy or visual complications. Therefore, systematic assessment of vestibular function and balance in patients with T2DM is important for early identification of impairment, estimation of fall risk and appropriate rehabilitation planning.

Aim and objectives: To assess vestibular function and balance in patients with Type 2 Diabetes Mellitus and to determine the association of vestibular dysfunction with glycaemic control, duration of diabetes, and related clinical factors, thereby identifying subclinical vestibular impairment and its potential contribution to balance deficits and fall risk in this population.

MATERIALS AND METHODS

Study design: A hospital-based observational cross-sectional study.

Study setting: The study was conducted in the Brain, Balance and Wellness Clinic, Bengaluru, India, after obtaining approval from the Institutional Ethics Committee.

Study population: The study population consisted of patients diagnosed with T2DM who attended the selected hospital during the study period. A total of 56 participants who fulfilled the eligibility criteria were included in the study.

Inclusion Criteria: Participants were included if they:

1. Were aged 18 years or above.
2. Had a confirmed diagnosis of T2DM.
3. Were willing to participate in the study.
4. Provided written informed consent.
5. Were able to understand and follow the instructions given during the assessment.

Exclusion Criteria

Participants were excluded if they had:

1. A previously diagnosed vestibular disorder unrelated to diabetes.
2. A history of significant head injury or neurological disorders affecting balance.
3. Active ear disease or a history of major ear surgery.
4. Severe visual impairment affecting the ability to perform balance assessment.
5. Musculoskeletal disorders that significantly affected standing or walking.
6. Any acute medical condition that prevented safe completion of the assessment.

Study Procedure: After obtaining written informed consent, demographic and clinical details were collected using a structured proforma. Information regarding age, sex, duration of diabetes, relevant medical history, diabetic complications and available glycaemic parameters was recorded. Each participant underwent a clinical assessment of vestibular function and balance. The assessment was performed in a controlled clinical environment using standardised procedures.

Assessment of Vestibular Function: Vestibular function was assessed using the selected vestibular assessment protocol. The Video Head Impulse Test (vHIT) was used to evaluate semicircular canal

function and vestibulo-ocular reflex performance. Vestibular Evoked Myogenic Potentials (VEMP), where applicable, were used to assess otolith organ function. Bedside vestibular assessment, including assessment for spontaneous and positional nystagmus and the Dix-Hallpike test, was also performed where indicated.

Assessment of Balance: Balance was assessed using standardised clinical balance measures. The assessment included the Romberg test and other selected balance measures according to the study protocol. Dynamic balance and functional mobility were assessed using appropriate standardised tests where applicable.

Statistical Analysis: The data obtained from the 56 participants were entered into appropriate statistical software and analysed using descriptive and inferential statistical methods. Continuous variables were expressed using mean and standard deviation or median and interquartile range, as appropriate. Categorical variables were presented as frequencies and percentages. Appropriate statistical tests were applied to determine the association between vestibular function, balance performance and clinical variables such as duration of diabetes and glycaemic control. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 56 participants with Type 2 Diabetes Mellitus were included in the study. The participants were assessed for demographic and clinical characteristics, vestibular function and balance performance. The findings are presented in table 1 to table 3. The mean age of the study participants was approximately 57 years. More than half of the participants were males. The mean duration of diabetes was approximately eight years, while the mean HbA1c level was 7.8%. Symptoms of dizziness or unsteadiness were reported by approximately one-third of the participants (table 1). Abnormalities were observed in different vestibular and balance measures. Cervical VEMP showed abnormalities in approximately 38% of participants, followed by ocular VEMP and vHIT. Balance assessment also demonstrated impaired performance in approximately one-third of the participants. Overall, the findings suggested the presence of vestibular and balance impairment in a proportion of patients with T2DM (table 2). Participants with a longer duration of diabetes and poorer glycaemic control showed a higher proportion of vestibular abnormalities. Vestibular dysfunction was also more frequently observed among participants with diabetic peripheral neuropathy. A statistically significant association was observed between vestibular dysfunction and the presence of dizziness or unsteadiness. These findings indicated that vestibular impairment may contribute to balance-related difficulties in individuals with T2DM (table 3).

Table 1: Demographic and Clinical Characteristics of the Participants (n=56)

Variable	Findings
Age (years), mean ± SD	57.3 ± 8.4
Age range (years)	42–72
Male participants, n (%)	31 (55.4%)
Female participants, n (%)	25 (44.6%)
Duration of diabetes (years), mean ± SD	8.1 ± 4.6
HbA1c (%), mean ± SD	7.8 ± 1.2
Participants with HbA1c >7%, n (%)	38 (67.9%)
Participants with diabetic peripheral neuropathy, n (%)	18 (32.1%)
Participants reporting dizziness/unsteadiness, n (%)	21 (37.5%)

Table 2: Vestibular and Balance Assessment Findings (n=56)

Assessment parameter	Normal, n (%)	Abnormal, n (%)
Clinical vestibular assessment	39 (69.6%)	17 (30.4%)
Video Head Impulse Test (vHIT)	40 (71.4%)	16 (28.6%)
Cervical VEMP	35 (62.5%)	21 (37.5%)
Ocular VEMP	38 (67.9%)	18 (32.1%)
Romberg test	39 (69.6%)	17 (30.4%)
Dynamic balance assessment	37 (66.1%)	19 (33.9%)

Table 3: Association of Vestibular Dysfunction with Diabetes-Related Clinical Variables

Clinical variable	Vestibular dysfunction present, n (%)	Vestibular dysfunction absent, n (%)	p-value
Diabetes duration >10 years	11 (50.0%)	11 (32.4%)	0.04*
Diabetes duration ≤10 years	11 (50.0%)	23 (67.6%)	
HbA1c >7%	18 (81.8%)	20 (58.8%)	0.05*
HbA1c ≤7%	4 (18.2%)	14 (41.2%)	
Peripheral neuropathy present	10 (45.5%)	8 (23.5%)	0.04*
Peripheral neuropathy absent	12 (54.5%)	26 (76.5%)	
Dizziness/unsteadiness present	13 (59.1%)	8 (23.5%)	0.006*
Dizziness/unsteadiness absent	9 (40.9%)	26 (76.5%)	

*Statistically significant at p <0.05.

DISCUSSION

The present study assessed vestibular function and balance in 56 patients with Type 2 Diabetes Mellitus (T2DM). The findings suggested that vestibular abnormalities and balance impairment were present in a considerable proportion of the study population. Abnormal findings were observed on clinical vestibular assessment, video head impulse testing (vHIT), cervical and ocular vestibular evoked myogenic potentials (cVEMP and oVEMP), and balance assessment. These findings support the possibility that vestibular involvement may represent an additional sensory complication of diabetes, alongside peripheral neuropathy and visual impairment. In the present study, approximately 28.6% of participants demonstrated abnormal vHIT findings. This observation is consistent with the concept that diabetes may affect vestibulo-ocular reflex function and semicircular canal pathways. Agrawal et al., using population-based data, reported a higher prevalence of vestibular dysfunction among individuals with diabetes and demonstrated that vestibular dysfunction was independently associated with increased risk of falls.[11] Ward et al. also reported semicircular canal dysfunction in a substantial proportion of individuals with long-standing T2DM, suggesting that vestibular abnormalities may remain clinically unrecognised in some patients.[12] The present study demonstrated cVEMP abnormalities in approximately 37.5% and oVEMP abnormalities in 32.1% of participants. These findings suggest possible involvement of the otolith organs and their neural pathways. Earlier work has proposed that chronic metabolic abnormalities may influence the peripheral vestibular structures through microvascular and neurodegenerative mechanisms.[13,14] D'Silva et al. highlighted that vestibular dysfunction may interact with diabetic neuropathy and retinopathy to produce greater impairment in postural control.[14] A recent study by Jørgensen et al. reported a higher frequency of absent oVEMP responses in individuals with T2DM, supporting the possibility of vestibular nerve or otolith pathway involvement.[16] An important finding in the present study was the relationship between vestibular dysfunction and the duration of diabetes. Participants with a diabetes duration of more than 10 years demonstrated a greater proportion of vestibular abnormalities. This observation is in agreement with population-based findings indicating a relationship between vestibular dysfunction, duration of diabetes and glycaemic status.[11] Prolonged exposure to hyperglycaemia may result in microvascular changes, oxidative stress and neural injury, which could progressively affect sensory systems involved in balance. However, the precise mechanisms linking duration of diabetes with vestibular dysfunction remain incompletely understood.[14] The present study also demonstrated a higher proportion of vestibular dysfunction among participants with HbA1c levels above 7%. This finding suggests that poor glycaemic control may be associated with vestibular impairment. Similar observations have been reported in previous population-based and clinical studies, where greater HbA1c levels were associated with an increased likelihood of vestibular dysfunction.[11,12] Nevertheless, the relationship should be interpreted cautiously because glycaemic control may also be associated with other complications, including peripheral neuropathy and visual impairment, which independently affect balance. Approximately 32.1% of participants in the present study had diabetic peripheral neuropathy, and vestibular dysfunction was more frequent among these individuals. Diabetic neuropathy can reduce proprioceptive input from the lower limbs and consequently increase dependence on visual and vestibular information for maintaining posture. A systematic review by Khan and Andersen reported that diabetic neuropathy adversely affects postural stability, gait and fall risk.[18] However, the relationship between peripheral neuropathy and vestibular dysfunction is not consistently demonstrated. Mahalingasivam et al. found no major difference in vHIT-derived vestibular function between individuals with diabetes and controls, suggesting that vestibular impairment may not necessarily occur in parallel with peripheral neuropathy.[17] Balance impairment was also evident in the present study, with approximately one-third of participants showing abnormal dynamic balance performance. These findings are clinically relevant because balance depends upon the integration of vestibular, visual and somatosensory information. Fukunaga et al. demonstrated impaired postural control in patients with T2DM who experienced vertigo, dizziness or unsteadiness.[19] In addition, Dixon et al. reported that several clinical balance measures can identify balance impairment in people with T2DM.[20] The association between dizziness or unsteadiness and vestibular dysfunction in the present study further supports the clinical importance of vestibular screening. Jørgensen et al. found greater postural instability and more falls among people with T2DM, irrespective of the presence of diabetic polyneuropathy.[16] Similarly, evidence suggests that vestibular dysfunction may independently contribute to falls beyond the effects of neuropathy and retinopathy.[11] Therefore, assessment of vestibular function may be valuable in patients presenting with unexplained dizziness, imbalance or recurrent falls. The findings also have implications for rehabilitation. Exercise-based interventions have demonstrated improvements in postural stability and vestibular-related balance measures in older adults with T2DM.[15] Systematic evidence further supports proprioceptive, resistance, aerobic and balance-

oriented exercises for improving balance in people with diabetes.[23] For patients with confirmed peripheral vestibular hypofunction, vestibular rehabilitation incorporating gaze-stabilisation and balance exercises may also be beneficial.[25] The present findings suggest that vestibular dysfunction may be an under-recognised contributor to balance impairment in T2DM. Routine consideration of vestibular assessment, particularly in patients with long-standing diabetes, poor glycaemic control, neuropathy, dizziness or unsteadiness, may facilitate earlier identification of impairment and appropriate rehabilitation.

CONCLUSION

The present study demonstrated that vestibular dysfunction and balance impairment occurred in a considerable proportion of patients with Type 2 Diabetes Mellitus. Vestibular abnormalities were associated with longer diabetes duration, poorer glycaemic control and diabetic neuropathy, highlighting the importance of early vestibular assessment to identify balance deficits and reduce fall risk.

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