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*Research Article*

# Effect of HbA1c Level on Vestibular System among Patients with Diabetes Mellitus

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**ABSTRACT**

**Background & Aim:** Sensorineural Hearing Loss (SNHL) resulting from microangiopathy is one of the recognised consequences of Diabetes Mellitus (DM), a multisystem illness. Although there is enough evidence linking diabetes to hearing difficulties, less is known about how the disease affects the vestibular system, particularly in the Indian population. The purpose of this research is to look at the relationship between vestibular function and HbA1c levels, a crucial indicator of glycaemic management, in individuals with Type-II Diabetes Mellitus (T2DM). **Method:** A cross-sectional research including 167 T2DM patients between the ages of 31 and 60 was carried out. Cervical and Ocular Vestibular Evoked Myogenic Potentials (cVEMP & oVEMP) along with subjective test (Head Impulse Test & Timed Up and Go) were used to assess vestibular function, and patients were classified into two groups according to their HbA1c levels. T2DM controlled DM (HbA1c < 7%) and uncontrolled DM (HbA1c > 7.1%). **Results & Conclusion:** As shown by the fact that 100% of patients with uncontrolled diabetes had positive Head Impulse Test (HIT) & Timed Up and Go (TUG) test, the data demonstrated a substantial link between vestibular dysfunction and diabetes. Comparing the uncontrolled DM group to the controlled diabetes group, significant VEMP latency delays were seen, especially for the cVEMP and oVEMP among uncontrolled T2DM than controlled T2DM. These results imply that chronic hyperglycemia may affect vestibular function, raising the possibility of falls and balance issues in diabetics. Remarkably, there were no significant variations in vestibular responses between subjects who were male and female. This research emphasises the need of glycaemic management in maintaining vestibular function in individuals with uncontrolled T2DM than controlled T2DM. It also emphasises the necessity of early detection and vestibular deficit rehabilitation in order to avoid related consequences like falls. It is necessary to conduct more research to investigate the underlying processes and develop standardised techniques for the evaluation of vestibular function in individuals with DM.

**Key Words:** T2DM, HbA1c, Vestibular System, VEMP, HIT, TUG

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## INTRODUCTION

Diabetes mellitus (DM) affects many different organs and systems and is a multisystemic, complicated illness. The International Diabetes Federation estimates that 40.9 million people in India have diabetes now, and that number is projected to rise to 69.9 million by 2025 (Sicree et al., 2006) [1]. Numerous biochemical mechanisms, including the synthesis of polyols, glycosaminoglycans, increased protein kinase activity, and advanced glycation end products, are involved in the pathogenesis of diabetes mellitus (DM), and they all contribute to microvascular damage, also known as "microangiopathy" (Wada & Yagihashi, 2005) [2]. Sensorineural hearing loss (SNHL) in diabetics has been linked in large part to this microangiopathy (Makishima & Tanaka, 1971) [3]. Moreover, studies have shown a correlation between diabetic SNHL and auditory neuropathy, which often presents as a late consequence (Friedman et al., 1975; Naufal P, Schuknecht, 1972) [4,5].

In addition, expanding upon these discoveries, we investigated analogous pathways concerning vestibular system in individuals with diabetes. Even though the connection between diabetes and hearing impairments is widely known, little study has been done on vestibular involvement in diabetic patients, especially in the Indian community. Furthermore, no research has looked closely at the connection between vestibular system and glycaemic management in diabetes mellitus. In order to enable prompt care and rehabilitation of these issues, it is essential to take into account diabetes mellitus as a possible cause of both SNHL and vestibular system due to its effects on many sensory systems, including hearing and balance Xipeng et al. (2013) [6]. Our study primarily examines the connection between HbA1c (glycaemic) and vestibular system in Type-II DM. As the main indicator of diabetes control, They used haemoglobin A1C (HbA1c), a sensitive metric that hasn't been used much in earlier studies Xipeng et al. (2013) & Webster et al. (2015) [6 & 7].

The vestibular system, which is in charge of preserving equilibrium, is made up of five sensory organs found in the inner ear: two otolith organs, the saccule and utricle, which feel gravity and linear motion, and three semicircular canals (SCC), which detect angular head motions. In order to stabilize vision and maintain balance during movement, these sensory organs transmit signals to the brainstem via the vestibular nerve (cranial nerve VIII), where they combine with other reflexes including the vestibulo-ocular reflex (VOR) and vestibulo-spinal reflex (VSR). Quantitative procedures such as Vestibular Evoked Myogenic Potentials (VEMPs), used to examine vestibular function.

Long-term hyperglycaemia in diabetics may impair vestibular function because it reduces metabolic vasculature and causes inflammation in the inner ear. Vestibular system has received little attention, despite the fact that peripheral neuropathy and vision problems are often blamed for falls among persons with diabetes (PWD). Since the vestibular system is essential for balance, problems in it may raise the risk of falls in diabetics on their own. A compromised vestibular system may worsen postural control and decrease visual acuity during head movements, which raises the risk of falls ADA (2015); Kim et al. (2012); Curthoys (2012). [8, 9 & 10]

In light of these discoveries, our work aims to improve treatment approaches for diabetes-related hearing and balance problems by assessing the connection between glycaemic control and vestibular system in Type-II DM patients. Our goal is to provide a more thorough knowledge of the effects of glycaemic status on the vestibular and auditory systems by using HbA1c to evaluate diabetes management.

## AIM AND OBJECTIVES

The purpose of this study is to examine the association between vestibular system function and glycaemic management, as measured by HbA1c levels, in patients with Type 2 Diabetes Mellitus (T2DM).

- To analyse the correlation between HbA1c levels and vestibular system function, as measured by cervical and ocular VEMP tests.
- To compare vestibular system performance in individuals with well-controlled diabetes (HbA1c < 7%) and those with poorly controlled diabetes (HbA1c > 7.1%).

## MATERIALS AND METHOD

Patients diagnosed with Type-II Diabetes based on the diagnostic standards established by the American Diabetes Association (ADA) [8] were the subject of this observational cross-sectional research. There were 167 individuals in the sample, and their ages ranged from 31 to 60. Patients with Type-II Diabetes Mellitus (T2DM) diagnosis was a prerequisite for inclusion; patients with Type-I Diabetes, pregnancy, ototoxic medication use, ear discharge, head injury history, noise exposure, deafness in the family history, and a host of other medical disorders precluded participation. Moreover, the research did not include people who did not provide their permission.

The Institutional Ethics Committee granted ethical approval, and each subject gave written informed permission. An oto-neurological examination and a thorough medical history were part of the investigation. The Dizziness Handicap Inventory (DHI) was used to assess the patients, and other investigations were conducted. HbA1c, lipid profiles, fasting and postprandial blood sugar levels, and sugar tests among the diabetic evaluations. Vestibular Evoked Myogenic Potentials (c & o - VEMPs) and subjective test (HIT & TUG test) were two methods used in vestibular assessments.

**HIT & TUG Test:** Vestibular function and balance are evaluated using the Head Impulse Test (HIT) and the Timed Up and Go (TUG) test. The vestibulo-ocular reflex (VOR), which maintains vision when moving the head, is assessed by the HIT. While the patient concentrates on a single place throughout the test, the doctor rapidly moves the patient's head. Corrective eye movements suggest semicircular canal malfunction or VOR. By timed how long it takes a person to get out of a chair, walk three meters, turn around, and sit back down, the TUG test assesses functional mobility. A duration longer than 12–14 seconds indicates a larger chance of falling.

The ADA's 2017 [8] criteria were used to classify the state of glucose control based on HbA1c values. Two types of patients were identified: HbA1c >7.1% & above and controlled (HbA1c ≤7%). HbA1c was the main indicator used to classify glycemic control. Microsoft Excel and SPSS software version 22 (IBM, Chicago, USA) were used for data analysis.

## RESULTS

**Table 1 Association between HbA1c & HIT Test**

The association between the findings of the Head Impulse Test (HIT) and the HbA1c levels which were divided into Control DM (HbA1c < 7%) and Uncontrolled DM (HbA1c > 7.1%) categories was evaluated using a cross-tabulation analysis. With a Chi-Square value of 150.910 and a p-value of 0.000, the Pearson Chi-Square test showed a statistically significant correlation between HIT findings and HbA1c levels, proving that the link is not the product of chance. There was a significant correlation between uncontrolled diabetes and altered vestibular function: in the Control DM group, 92.5% of individuals had a negative HIT, while only 7.5% had a positive result. In the uncontrolled group, on the other hand, 100% of patients had positive HIT findings (Table 1).

| HIT - HbA1c | | | | | |
|---|---|---|---|---|---|
| HIT | HbA1c | | Total | Pearson Chi-Square | P value |
| | Controlled DM | Uncontrolled DM | | | |
| NO | 37 | 0 | 37 | 150.910[a] | 0.000 |
| | 92.5% | 0.0% | 22.2% | | |
| YES | 3 | 127 | 130 | | |
| | 7.5% | 100.0% | 77.8% | | |
| Total | 40 | 127 | 167 | | |
| | 100.0% | 100.0% | 100.0% | | |

**Table 1 Association between HbA1c & HIT Test**

**Table 2 Link between vestibular dysfunction and HbA1c**

Table 2 shows that, there is a high link between vestibular dysfunction and HbA1c levels, and the risk estimate for individuals in the Control DM group suffering a negative HIT was 43.333, with a 95% confidence range of 14.161 to 132.605. After 167 genuine cases were examined, it was evident from the analysis that people with uncontrolled diabetes had a much higher likelihood of having vestibular dysfunction, as indicated by a positive HIT.

| Risk Estimate | | | |
|---|---|---|---|
| | Value | 95% Confidence Interval | |
| | | Lower | Upper |
| cohort HbA1c = Control | 43.333 | 14.161 | 132.605 |
| N of Valid Cases | 167 | | |

**Table 2 Link between vestibular dysfunction and HbA1c**

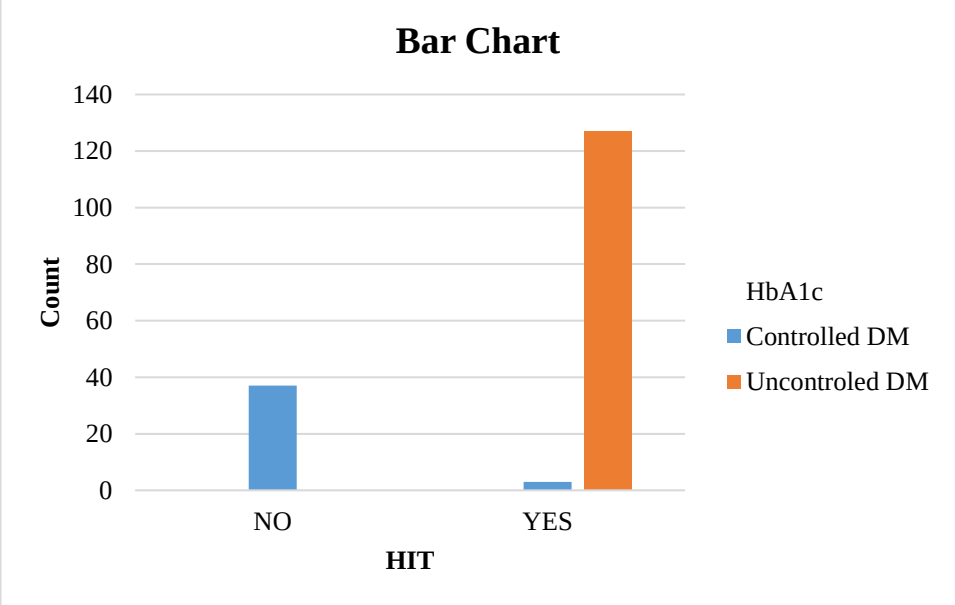


**Figure 1 Individual with HIT Test among controlled T2DM & uncontrolled T2DM**

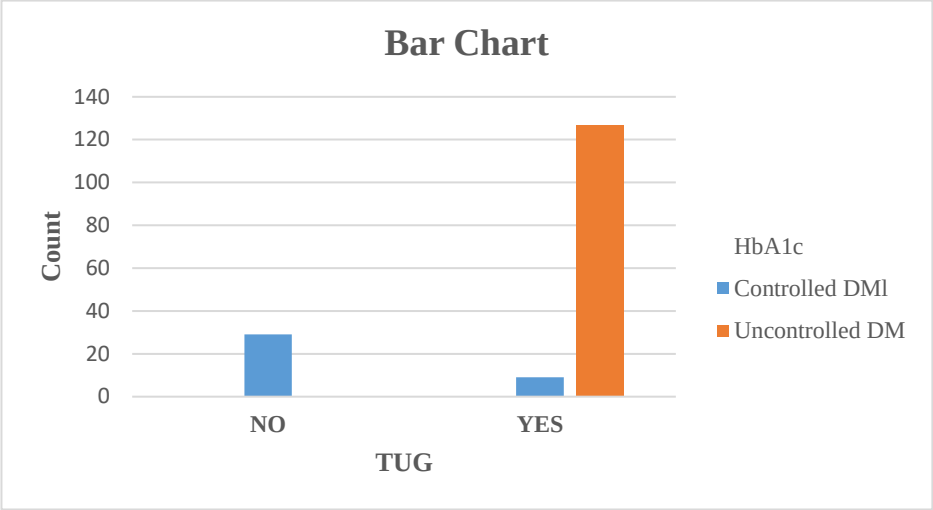


**Figure 2 Individual with TUG Test among controlled T2DM & uncontrolled T2DM**

**cVEMP and oVEMP reflex measurement**

The response maxima, which, depending on the stimulus, happen at around 13 and 23 ms for the cVEMP and 10 and 15 ms for the oVEMP, are where amplitudes and latencies are assessed. The amplitude is calculated as the difference between the peak amplitudes. If a measurement of SCM muscle activity is available, "corrected amplitude" for cVEMPs may be computed to account for the strength of the muscle contraction.

**Table 3 Association between VEMP (c &o) test and T2DM**

Significant variations in a number of VEMP parameters were seen in the T-test findings comparing vestibular function between the groups with controlled and uncontrolled diabetes. With a t-value of -2.845 and a p-value of 0.005, the cervical VEMP (cVEMP) Right P13 showed that the latencies of the uncontrolled group (mean = 13.9512, SD = 3.60660) were significantly greater than those of the control group (mean = 13.0375, SD = 0.16899). Left P13 (t = -5.040, p = 0.000) and Left N23 (t = -3.068, p = 0.003) showed comparable significant differences. Significant differences were seen in Right N10 (t = -7.709, p = 0.000) and Left P15 (t = 6.078, p = 0.000) in ocular VEMP (oVEMP), indicating inferior vestibular function in the uncontrolled diabetic group in comparison to controls. On the other hand, cVEMP Right N23 showed no discernible change (t = -0.238, p = 0.812). These findings imply that impaired vestibular function, or delayed vestibular evoked potentials, is linked to uncontrolled diabetes.

| HbA1c | | N | Mean | Std. Deviation | t | P value |
|---|---|---|---|---|---|---|
| cVEMP Right P13 | Controlled DM | 40 | 13.0375 | 0.16899 | -2.845 | 0.005 |
| | Uncontrolled DM | 127 | 13.9512 | 3.60660 | | |
| cVEMP Right N23 | Controlled DM | 40 | 22.8700 | 0.57566 | -0.238 | 0.812 |
| | Uncontrolled DM | 127 | 23.0000 | 6.06906 | | |
| cVEMP Left P13 | Controlled DM | 40 | 13.0000 | 0.00000 | -5.040 | 0.000 |
| | Uncontrolled DM | 127 | 13.8142 | 1.82042 | | |
| cVEMP Left N23 | Controlled DM | 40 | 23.0000 | 0.00000 | -3.068 | 0.003 |
| | Uncontrolled DM | 127 | 23.8165 | 2.99925 | | |
| oVEMP Right N10 | Controlled DM | 40 | 11.8025 | 3.07342 | -7.709 | 0.000 |
| | Uncontrolled DM | 127 | 17.1457 | 5.56899 | | |
| oVEMP Right P15 | Controlled DM | 40 | 20.6650 | 5.14381 | 8.797 | 0.000 |
| | Uncontrolled DM | 127 | 12.8433 | 4.05017 | | |
| oVEMP Left N10 | Controlled DM | 40 | 11.0000 | 0.00000 | -5.589 | 0.000 |
| | Uncontrolled DM | 127 | 13.0134 | 4.05970 | | |
| oVEMP Left P15 | Controlled DM | 40 | 23.0000 | 0.00000 | 6.078 | 0.000 |
| | Uncontrolled DM | 127 | 20.9294 | 3.82386 | | |

**Table 3 Association between VEMP (C & O) test and T2DM**

**Table 4 Relationship between Gender & VEMP (c & o) Test**

There were no statistically significant variations in vestibular function between male and female participants in the research that compared their cervical and ocular VEMP responses. Males exhibited a mean delay of 13.91 ms for the C VEMP Right P13, whereas females had 13.47 ms, with a p-value of 0.380. In a similar vein, the male and female cVEMP Right N23 mean latencies were 23.14 and 22.72 ms, respectively (p = 0.619). There were no significant differences for other measurements, suggesting that there are no substantial sex-based vestibular differences, despite the fact that males had somewhat higher

cVEMP Left P13 values, which were almost significant (p = 0.055).

| Gender | | N | Mean | Std. Deviation | T | P value |
|---|---|---|---|---|---|---|
| cVEMP Right P13 | Male | 99 | 13.9111 | 3.14019 | 0.879 | 0.380 |
| | Female | 68 | 13.4721 | 3.21224 | | |
| cVEMP Right N23 | Male | 99 | 23.1384 | 4.98536 | 0.498 | 0.619 |
| | Female | 68 | 22.7221 | 5.74560 | | |
| cVEMP Left P13 | Male | 99 | 13.8192 | 1.35997 | 1.937 | 0.055 |
| | Female | 68 | 13.3279 | 1.91902 | | |
| cVEMP Left N23 | Male | 99 | 23.8141 | 2.08479 | 1.144 | 0.254 |
| | Female | 68 | 23.3397 | 3.27520 | | |
| oVEMP Right N10 | Male | 99 | 15.1778 | 5.93058 | -1.943 | 0.054 |
| | Female | 68 | 16.8676 | 4.86015 | | |
| oVEMP Right P15 | Male | 99 | 14.2535 | 6.02231 | -1.324 | 0.187 |
| | Female | 68 | 15.3912 | 4.49433 | | |
| oVEMP Left N10 | Male | 99 | 12.4818 | 3.81815 | -0.211 | 0.833 |
| | Female | 68 | 12.6029 | 3.39156 | | |
| oVEMP Left P15 | Male | 99 | 21.4827 | 3.43238 | 0.243 | 0.808 |
| | Female | 68 | 12.6029 | 3.39156 | | |

**Table 4 Relationship between Gender & VEMP (c & o) Test**

## DISCUSSION

Our study's results are consistent with other studies that have shown a greater prevalence of vestibular impairment in people with T2DM. Our findings show that all vestibular end organs were compromised in T2DM subjects, with the saccule, utricle, and superior and lateral semicircular canals (SCCs) showing the most impairment. Fascinatingly, the posterior SCC seems to have been mostly spared, which is consistent with patterns seen in individuals with uncontrolled T2DM. This is in line with previous research by Biurrun et al. (1991), [11] which found a dose-response association between individuals with T2DM and chronic hyperglycemia and reduced vestibular function.

One of the study's main strengths is the way in which newly designed vestibular tests that isolate function in particular organs were used to analyse each vestibular end organ separately in a well-characterized cohort with T2DM. This makes it possible to comprehend dysfunctional patterns more clearly a technique that Curthoys et al. (2012) [10] also emphasises. Our research supports earlier results by Konukseven et al. (2014) [12], who found that people with T2DM have delayed VEMP latencies in both ocular and cervical VEMPs. The authors Kamali et al. (2013) [13] propose that these delays might be indicative of neuropathic damage akin to that seen in peripheral neuropathy, where delayed nerve conduction is regarded as a diagnostic sign.

Our research also revealed a greater incidence of falls in those with type 2 diabetes, which provides further evidence for the association between diabetes and a reduction in functional mobility. Notable inherent risk factors for falls were reduced visual acuity and difficulties getting up from a chair without assistance, especially in individuals with severe uncontrolled T2DM. These results are consistent with other studies by Volpato et al. (2005); Alvarenga et al. (2010) [14, 15], which also found that T2DM patients had higher levels of impairment. There are a few restrictions, however, that must be noted. The study's cross-sectional design makes it impossible to establish a cause and effect link between vestibular dysfunction and diabetes as well as these confounding variables might have affected the results. Furthermore, it is still difficult to diagnose bilateral vestibular loss since some healthy people might have decreased or non-existent VEMP responses. Determining the lower limit of normal amplitude, as proposed by Alvarenga et al. (2010); Agrawal et al. (2013); Welgampola & Colebatch (1971) [15, 16 & 22], may help improve the diagnosis of vestibular disorders in these kinds of situations.

According to Xipeng et al. (2013); Young et al. (2002); Zuniga et al. (2014) [6, 18, 23], T2DM patients had a greater incidence of missing VEMP responses, which may be related to vestibulocochlear nerve damage brought on by persistent hyperglycemia. Persistent hyperglycemia may cause vestibular sensitivity to be diminished by affecting inner ear function. When comparing people with managed type 2 diabetes, other VEMP metrics, such delayed negative and positive latencies, did not significantly vary, suggesting that hyperglycemia may only impair certain vestibular function components. Diverse techniques, such as varying combinations of objective tests, have been used to evaluate vestibular function, which may account for the vast range in the reported prevalence of vestibular dysfunction (VD) among individuals with type 2 diabetes. Taylor et al. (2015); Verrecchia et al. (2016); Zhao et al. (2010) [20, 21, 24] Furthermore, as mentioned by Arshad & Seemungal (2016) [19]; variables including age-related decline of peripheral vestibular function could potentially have a role in the variation in VD prevalence in this group.

## CONCLUSION

This research demonstrates a strong correlation between vestibular system function and glycaemic management (as determined by HbA1c levels) in individuals with T2DM. Delay in latencies in both cervical and ocular Vestibular Evoked Myogenic Potentials (c & o VEMPs) and positive Head Impulse Test (HIT) & Time Up & Go (TUG) test findings indicate a robust correlation between uncontrolled diabetes (HbA1c >

7.1%) and compromised vestibular function. In particular, vestibular dysfunction was more common in individuals with uncontrolled diabetes, indicating a detrimental effect of persistent hyperglycemia on the vestibular system. The results highlight how crucial it is to keep an eye on diabetes patient's vestibular health, especially if they have poor glycaemic control. These patients vestibular dysfunction may be a factor in their elevated fall risk, compromised balance, and decreased functional mobility all of which are serious issues for their general health and quality of life. Early identification and intervention, particularly better glycaemic control, might help reduce these consequences given the considerable effect of diabetes on the vestibular system. All things considered, this work adds to the increasing amount of data that connects diabetes to multisensory deficits, highlighting the need of a thorough approach to diabetic care that include the diagnosis and treatment of vestibular and balance-related problems.

## CONFLICT OF INTEREST STATEMENT

The authors have no conflicts to declare

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