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EVALUATION OF BALANCE AMONG PATIENTS WITH TYPE 2 DIABETES MELLITUS: A CROSS – SECTIONAL STUDY

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Abstract – In elderly diabetic patients with neuropathy, diabetic peripheral neuropathy (DPN) impairs balance and results in balance issues, which raise the risk of falls for those who have it. The need of this study was to evaluate the balance in Type 2 Diabetes Mellitus without Neuropathy so that it will help to improve the balance in early stage. This study has specifically focused on static, dynamic, proactive, vestibular, and ocular balance by using different components of the MiniBEST (Mini Balance Evaluation System Test) Scale. This is a cross – sectional study including 70 participants having Type 2 Diabetes Mellitus (T2DM) without neuropathy. All the participants were screened for neuropathy using MNSI (Michigan Neuropathy Screening Instrument), further they were assessed for balance impairment using MiniBEST and MCTSIB (Modified Clinical Test for Sensory Interaction on Balance) scale. A correlation analysis was done using the 4 Sub components of the MiniBEST scale and the MCTSIB scale with age, BMI and T2DM duration. Participants with T2DM demonstrated reduced balance performance, despite having no clinical signs of peripheral neuropathy.

Keywords – Type 2 Diabetes Mellitus, Balance, Neuropathy

I. Introduction –

Diabetes is among the largest global health emergencies of the running century, running among 10 leading causes of mortality along with cardiovascular diseases (CVD), respiratory diseases and cancer (Viswanathan et al, 2021). One of the biggest global public health issues is the swift spread of type-2 diabetes. In addition to genetic predisposition, changes in dietary preferences and lifestyle are making emerging countries the epicentres of cardiometabolic illnesses. In South Asian nations, particularly India, diabetes has emerged as a significant independent risk factor for cardiovascular illnesses Sedentary lifestyles and unhealthy, high-calorie diets pose a threat to urban Indian living, lowering the metabolic status of "thin-fat Indians" and making them more susceptible to metabolic diseases.(Pandey et al., 2015)

Insulin resistance, relative insulin insufficiency, and hyperglycemia are the hallmarks of type 2 diabetes mellitus (T2DM). Currently, about 23 million people in the US are among the 366 million people worldwide who have diabetes mellitus. By 2030, this figure will rise to 552 million. Type 2 DM is associated with many chronic complications, involving many organs including brain and nervous system. Central nervous system-related complications of diabetes has been known for more than 100 years by researchers and clinicians.(Damanik & Yunir, 2021)

The fundamental foundational function for staying upright and avoiding falls is known as balance control, which can be either proactive (anticipatory) or reactive (compensatory). Proactive control involves shifting the body's center of pressure (COP) before the voluntary movement begins and engages the postural muscles of the legs and trunk to reduce the balance problems that would follow the impending motion. Although it may make it more difficult to carry out the desired voluntary action, inadequate proactive balance control would be less likely to induce a loss of balance because one may typically opt to do the movement more slowly.(Lee et al., 2018)

Reactive balance control involves postural reactions for balance recovery when peripheral sensory receptors detect unanticipated balance disturbances. Reactive balance control is studied using a conventional pattern that induces body sway through support surface disturbance and demonstrates that the trunk and leg muscles would be engaged to reverse the sway after a brief latency. In elderly persons and diabetic patients with neuropathy of unknown age, these balancing responses are delayed and lead to increased displacement of COP.(Lee et al., 2018). Balance is thought to be essential part of life, from basic behaviour like standing still to more complex ones like conversing on the phone or changing directions while walking and other daily tasks. (Haleem et al., 2024)

Reduced proprioceptive sensibility, decreased ankle mobility and range of motion, and decreased muscular strength, particularly in the ankle and foot plantar and dorsiflexors, have all been identified in people with DPN, which can impair balance or postural stability.(Venkataraman et al., 2019)

Three systems—visual, proprioceptive, and vestibular—all contribute significantly to posture regulation, particularly during dynamic tasks. In order to maintain postural control, the integration of these sensations controls the proper timing and scaling of outputs. The vestibular system is crucial for maintaining balance in addition to visual and somatosensory processes, particularly while the head is moving. It is known that vestibular dysfunction (VD) contributes to falls on its own. Reduced vestibular system sensitivity can change how one perceives motion, balance, and spatial orientation—all of which are essential for stability. (Komalasari et al., 2024a)

Zhang.L et al.,2019 conducted a study to explore the characteristics of vestibular dysfunctions and balance control in patients with Type 2 Diabetes Mellitus. The study included 51participant with Type 2 Diabetes Mellitus and 43 individuals (with a mean age of 36 ± 10) that have undergone vestibular function test and balance control capability tests. This study concluded that patient who are diagnosed with Type 2 Diabetes Mellitus somewhere have high incidence of vestibular dysfunctions.

Taking into consideration a study by (Lim et al., 2014a) whose purpose was to compare the balance ability of patients with Type 2 Diabetes Mellitus with Peripheral Neuropathy with patients with Type 2 Diabetes Mellitus without Peripheral Neuropathy. He included 42 subjects with Type 2 Diabetes Mellitus of age 40 years and older (in which 17 subject has Diabetic Peripheral Neuropathy and 25 were on Diabetic control), 18 adults were selected without Diabetes in Korean population. Then motor impairment, sensory impairment and functional assessment was done using the Balance Master System. The study's analysis reveals that patients with peripheral neuropathy and diabetes may have functional restrictions more frequently, and that patients with diabetes may experience a decline in dynamic balance stability more frequently than participants without diabetes. To the best of my knowledge, till date, there was no such study conducted in Indian population to observe whether there is any balance impairment in people with Type 2 Diabetes Mellitus without Neuropathy. The need of this study was to evaluate the balance in Type 2 Diabetes Mellitus without Neuropathy so that it will help to improve the balance in early stage.

II. Need of the Study –

Although there are so many types of balance, but this study specifically focuses on static, dynamic, proactive, vestibular, and ocular balance. There have been so many research and studies done but to the best of knowledge all of them are happened post diabetic neuropathy or either they are on other population.

This study focuses on assessing the balances among the patients diagnosed with diabetes mellitus, without diabetic neuropathy.

III. Aims and Objective –

To evaluate whether there is any balance impairment in patients with Type 2 Diabetes Mellitus without neuropathy.

IV. Methodology –

4.1. Sample – A total of 75 participants having Type 2 Diabetes Mellitus participated in this study. Subjects were selected using convenience sampling. Data was collect in camp held on different places in Kanpur, UP.

4.2. Ethical Clearance - The study was approved by the Institutional Ethical Committee of School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Kanpur on 27th January 2025 **(HEC number – 2025-Jan-002)** and was done in accordance with the Helinski Declaration revised in 2013 and National Ethical Guidelines for Biomedical Research involving Human participants, 2017. The study was registered on Clinical Trail Registry Index with CTRI number **CTRI/2025/02/080209.**

4.3. Study Design – The Cross – Sectional Study

4.4. Inclusion Criteria –

- Patient who are willing to give consent for the study
- Patient knowing English language
- Patients with Type 2 Diabetes Mellitus
- Age between 35 to 55 years
- All genders
- Having diagnosed with Type 2 Diabetes Mellitus at least from last 5 years.

4.5. Exclusion Criteria –

- Patients with Diabetic Neuropathy
- Impaired mobility
- Patients that have any sensory loss in the lower limb
- Any type of other diseases such as Obesity, Cardiovascular diseases, etc.
- Patient should not be involved in any type of physical activity that lasts for more than 2 hrs.
- Lower limb amputation or joint replacement
- Lumbar or lower limb fracture
- Undergone any surgery in previous 6 months

4.6. Variables –

- Independent variable – Type 2 Diabetes Mellitus
- Dependent Variable – Balance

4.7. Materials Used –

- Cotton
- Stopwatch
- Medium Density Viscoelasticity Foam Sheet
- Stationary Tools
- Tunning Fork (128 Hz)
- Reflex Hammer

4.8. Outcome Measures –

1) Michigan Neuropathy Screening Instrument – For screening neuropathy
2) Mini Balance Evaluation System Test (MiniBEST) – For balance evaluation
3) Modified Clinical Test of Sensory Integration on Balance (mCTSIB) – For balance evaluation

4.9. Procedure –

Patients with T2DM were assessed and screened for the study. A Written Informed Consent was obtained from each of the participants. After that each participant was assessed using the Michigan Neuropathy Screening Instrument and only people with T2DM without neuropathy were included in the study. Further, selection of participants was based on selection criteria. After that all the participants were assessed for their basic demographic details like age, height, weight, BMI and duration of Type 2 Diabetes Mellitus. Then they were assessed for the outcomes of reactive, anticipatory, vestibular, ocular, static and dynamic balance. The participants were assessed using MiniBEST which assesses Static, Dynamic, Anticipatory and Reactive Balance and mCTSIB which is frequently used for assessment of Ocular, Somatosensory and Vestibular Balance. Both the scales were found to be reliable and a valid measure for this assessment. A total of 75 participants were evaluated. Data of the participants was collected and analysed with the help of software IBM Statistical package (SPSS) Statistics 26.0 (IBM, ARMONK, NY, USA) Version.

Fig no. 4.1. Vibration Testing for Michigan Neuropathy Screening Instrument

Fig no. 4.2. Standing on Foam Sheet with Eye Closed (Mctsib)

V.Results –

Normality tests showed that Age and Duration of T2DM were not normally distributed ($p < 0.05$). However, BMI was normally distributed ($p = 0.200$).

Based on the results Kolmogorov–Smirnov tests, most variables in the study were not normally distributed ($p < 0.05$).

Table No. 5.1. Descriptive statistics of the outcome measures in the study

S. No.	Outcome	P Value
1.	MCTSIB	0.002
2.	MB_ANTI	0.001
3.	MB_REACT	0.001
4.	MB_SENS	0.001
5.	MB_DG	0.001

In Spearman Rank Correlation among Age, BMI, T2DM Duration and MCTSIB it appears not to be significantly related to any of the other variables (p>0.05). (Table no. 5.2)

Table No. 5.2. Spearman Rank Correlation among Age, BMI, T2DM Duration and MCTSIB

S. No.	Variables	Correlation	P Value
1.	Age	-0.169	0.147
2.	BMI	-0.045	0.700
3.	T2DM Duration	-0.126	0.281

Spearman Rank Correlation was calculated among Age, BMI, T2DM Duration and MB_ANTI, MB_REACT. MB_SENS and MB_DG separately. Correlation among Age, BMI, T2DM Duration and MB_ANTI showed that it is not significantly related to Age, BMI, or T2DM Duration. In correlation among Age, BMI, T2DM Duration and MB_REACT doesn't show any meaningful relationships with the other variables rather than age that show negative correlation.

Correlation among Age, BMI, T2DM Duration and MB_SENS showed that age was significantly associated with MB_SENS. No significant correlations were found between BMI, T2DM duration, and MB_SENS. Correlation among Age, BMI, T2DM Duration and MB_DG showed that age and BMI was significantly associated with MB_DG. Age has negative correlation with MB_DG, BMI showed a significant positive correlation with MB_DG while T2DM duration had no significant association. (Table no. 5.3)

Table No. 5.3. Spearman Rank Correlation was calculated among Age, BMI, T2DM Duration and MB_ANTI, MB_REACT. MB_SENS and MB_DG

S. No.	Variables	Correlation	P value	Correlation	P value	Correlation	P value	Correlation	P value
		MB_ANTI		MB_REACT		MB_SENS		MB_DG	
1.	Age	-0.082	0.486	-0.052	0.657	-0.229	0.048	-0.230	0.048
2.	BMI	0.213	0.066	0.080	0.497	0.053	0.654	0.272	0.018
3.	T2DM	0.085	0.470	0.066	0.573	0.009	0.941	0.028	0.814

VI. Discussion-

The findings of this study highlight the subtle but significant impact of Type 2 Diabetes Mellitus (T2DM) on balance control, even in the absence of clinically diagnosed neuropathy. Although peripheral neuropathy has traditionally been considered a primary contributor to postural instability in diabetic patients, our results suggest that balance impairments may begin to manifest before neuropathic symptoms become evident. The relationship between balance function, as measured by the Modified Clinical Test of Sensory Interaction on Balance (MCTSIB), and key clinical variables including age, body mass index (BMI), and duration of type 2 diabetes mellitus (T2DM) was assessed and results showed that **MCTSIB was not significantly correlated** with any of these factors ($p > 0.05$ for all comparisons). Specifically, although a weak negative correlation was observed between MCTSIB and age ($\rho = -0.169$), it did not reach statistical significance ($p = 0.147$). Similarly, BMI ($\rho = -0.045$, $p = 0.700$) and T2DM duration ($\rho = -0.126$, $p = 0.281$) were not meaningfully associated with balance performance.

This study also investigated the relationships between demographic and clinical variables—namely age, body mass index (BMI), and duration of type 2 diabetes mellitus (T2DM) with the subcomponents of MiniBEST scale (specifically MB_ANTI, MB_REACT, MB_SENS, and MB_DG) using Spearman rank correlation analysis. The findings reveal distinct associations, particularly with age and BMI, while T2DM duration showed no significant correlations with any of the subcomponents studied. Notably, **MB_ANTI** did not exhibit any statistically significant correlation with age, BMI, or T2DM duration, suggesting that Anticipatory balance may operate independently of these basic demographic and clinical factors. Similarly, **MB_REACT** showed no meaningful associations, although a weak negative correlation with age was observed; this trend did not reach statistical significance. These results may indicate that MB_ANTI and MB_REACT reflect metabolic processes not directly influenced by age-related or obesity-related changes.

In contrast, **MB_SENS** demonstrated a statistically significant negative correlation with age ($\rho = -0.229$, $p = 0.048$), indicating that metabolic sensitivity may decline with advancing age. This aligns with prior literature suggesting age-related deterioration in metabolic flexibility and insulin sensitivity. However, MB_SENS was not associated with BMI or T2DM duration, implying that aging, rather than body composition or disease duration, may be a more relevant factor in determining this aspect of metabolic function. The most pronounced associations were observed with **MB_DG**, which was negatively correlated with age ($\rho = -0.230$, $p = 0.048$) and positively correlated with BMI ($\rho = 0.272$, $p = 0.018$). These findings suggest that older individuals may have reduced capacity for metabolic degradation, while individuals with higher BMI may exhibit an upregulation or accumulation of degradation-related metabolites. Interestingly, no correlation was found between MB_DG and T2DM duration, reinforcing the notion that metabolic degradation processes may be more influenced by current physiological state (e.g., body weight and age) than by the chronicity of diabetes.

Overall, these findings underscore the differential impact of age and BMI on various metabolic pathways and highlight the importance of considering these variables when interpreting biomarker profiles in T2DM populations. The absence of associations with T2DM duration across all markers may reflect a heterogeneity in disease progression or the influence of confounding treatment variables, which were not accounted for in this study.

VII. Limitations –

This study has several limitations. The cross-sectional design limits causal inferences. The sample size may not have been large enough to detect subtle associations, particularly with T2DM duration. Additionally, other relevant covariates such as dietary patterns, etc. were not included and may influence the observed relationships.

VIII. Conclusion –

In summary, Age and BMI are significantly associated with specific subcomponents of MiniBEST, particularly MB_SENS and MB_DG, in individuals with T2DM. These findings may provide insight into age- and obesity-related metabolic alterations and could inform future research on metabolic profiling and risk stratification in diabetes care.

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