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Original Article

Effect of Duration of Type-2 Diabetes Mellitus on Audio-Visual Reaction Time: A Cross-sectional Study

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder that may affect the peripheral and central nervous systems, potentially influencing reaction time (RT) and functional performance.

Aim : This study aimed to assess auditory and visual reaction times using a standardized reaction-time apparatus among individuals with T2DM and compare RT performance according to diabetes duration.

Methods: A cross-sectional study was conducted among 30 individuals with T2DM. Participants were divided into Group A (0–5 years; n=15) and Group B (>5 years; n=15). Simple, discriminatory, and choice auditory and visual RTs were assessed using a standardized reaction-time apparatus developed by Anand Agencies, Pune. Between-group comparisons were performed using the independent-samples t-test or Mann–Whitney U test, as appropriate. Within-group comparisons were performed using the Friedman test.

Results: No significant differences were observed between groups for simple auditory, simple visual, discriminatory visual, choice auditory, or choice visual RTs ($p>0.05$). A significant difference was observed in discriminatory auditory RT ($U=169.00$, $p=0.020$), with Group A showing a higher mean RT (0.695 ± 0.198 s) than Group B (0.557 ± 0.141 s).

Conclusion: Diabetes duration was not consistently associated with auditory or visual reaction-time performance. The findings suggest that diabetes duration alone may not adequately reflect the neurological effects of T2DM.

Keywords: Cognitive Function; Diabetes Duration; Neurophysiology; Reaction Time; Sensorimotor Processing; Type 2 Diabetes Mellitus.

Introduction:

Diabetes mellitus (DM) is a long-term metabolic disorder marked by persistent elevations in blood glucose and the eventual onset of vascular and neuropathic complications. Irrespective of its underlying cause, DM shares a core hormonal defect: insulin deficiency [1]. Obesity , hypertension, combined hyperlipidaemia, and the cluster of abnormalities known as metabolic syndrome can precipitate or exacerbate type 2 DM [2]. Cognitive impairment is increasingly recognized as a significant complication of Type-2 diabetes mellitus (T2DM), affecting multiple cognitive domains such as memory, executive function, and processing speed. In a comprehensive meta-analysis of risk factors for cognitive decline in adults with T2DM, researchers identified poor glycemic control, insulin resistance, and microvascular complications as major contributors to cognitive deterioration, underscoring the multifactorial nature of diabetes-associated cognitive decline [3]. Wang et al. (2015) evaluated peripheral nerve function in asymptomatic individuals with Type 2 Diabetes Mellitus (T2DM) and latent autoimmune diabetes in adults (LADA) using nerve conduction studies. The study included 1,275 patients with T2DM and categorized them according to disease duration into three groups: <5 years, 5–14 years, and ≥15 years. The findings highlight the importance of considering diabetes duration when evaluating peripheral nerve function and provide a rationale for investigating whether increasing duration of T2DM is associated with changes in sensory–motor responses, including audio-visual reaction time [4].

Collectively, these findings indicate that the longer the exposure to T2DM, the higher the likelihood and severity of cognitive deficits. Reaction time (RT) is an important indicator of cognitive and sensorimotor function, reflecting the speed of information processing and sensorimotor integration. As RT assessment is simple, non-invasive, and objective, it may be useful for detecting subtle neurological and sensorimotor changes associated with Type 2 Diabetes Mellitus [5]. This study aimed to assess auditory and visual reaction times using a standardized reaction time apparatus among individuals with Type 2 Diabetes Mellitus (T2DM) and to compare reaction time performance across short and long durations of diabetes.

MATERIALS AND METHODS

A cross-sectional feasibility study was conducted among individuals diagnosed with Type 2 Diabetes Mellitus (T2DM). The study was conducted at Physiotherapy OPD, Surat. A total of 34 T2DM participants were screened out of which 30 participants with T2DM who fulfilled the inclusion and exclusion criteria were recruited using convenience sampling. (2 were excluded due to paralysis and 1 was excluded due to auditory impairment and other 1 was excluded due to not able to understand command). Participants were categorized into two groups based on the duration of T2DM: Group A: Duration of T2DM 0–5 years (n = 15) ; Group B: Duration of T2DM >5 years (n = 15). Disease duration was based on participant self-report and was not independently verified from medical records.The grouping was based on the rationale that increasing duration of T2DM may be associated with progressive neurological and sensory complications. Previous research has also categorized individuals according to diabetes duration when evaluating peripheral nerve function [4].

Inclusion criteria:

Participants will be eligible for inclusion if they are diagnosed cases of Type 2 Diabetes Mellitus, aged 45–75 years, and of either sex. Participants must be able to understand and follow basic verbal commands. Those with corrected vision using spectacles or contact lenses will be included, provided their visual function is adequate for participation. Participants with corrected hearing using functional and effective hearing aids will also be eligible. All participants must be willing to participate in the study and provide written informed consent.

Exclusion criteria:

Participants with Type 1 Diabetes Mellitus will be excluded from the study. Participants with neurological disorders such as stroke, Parkinson’s disease, Alzheimer’s disease, or other neurological conditions affecting motor or cognitive function will also be excluded. Individuals with diabetic neuropathy, diabetic retinopathy, other retinal pathologies, orthopaedic or rheumatological conditions limiting participation, or significant musculoskeletal deformities such as amputation or scoliosis will be excluded.

Participants with serious comorbidities, including peripheral artery disease, congestive heart failure, decompensated pulmonary disease, or symptomatic cardiac arrhythmias, will not be included. Individuals with a history of dizziness, significant visual or vestibular problems, uncorrected visual impairment, significant refractive errors, diagnosed hearing impairment, auditory processing disorders, or neurological or otological conditions affecting sensory processing will also be excluded. Participants with a history of or current use of illicit drugs or other psychoactive substances that may affect cognitive, sensory, motor, or physical performance will be excluded. Individuals who are unwilling to provide informed consent or unable to comply with the study procedures will also be excluded.

Standardized Testing Procedure:

Auditory and visual reaction times were assessed using an audio-visual reaction-time apparatus (Anand Agencies, Pune) under three conditions: simple, discriminatory, and choice reaction time, which served as the primary outcome measures. The study was initiated after obtaining ethical clearance from the institutional ethics committee. Following informed consent, demographic and clinical information, including age, sex, and duration of Type 2 Diabetes Mellitus, was recorded. All assessments were conducted by the principal investigator using the same reaction-time apparatus and standardized testing procedure to ensure consistency and reliability. The participant was seated comfortably in front of the apparatus, and the purpose and procedure of the test were explained clearly. Participants were instructed to maintain attention throughout the assessment and to respond as quickly and accurately as possible. Two practice trials were provided for each stimulus condition to familiarize the participant with the procedure. An adequate rest interval of approximately 30 seconds was provided between successive trials to minimize fatigue and maintain attention. For each reaction-time condition, three response trials were recorded, and the mean of the three trials was calculated and used for statistical analysis. For simple reaction time, the participant was required to respond to a single predetermined stimulus. For auditory simple reaction time, a beep sound was presented through the apparatus, and the participant was instructed to press the designated response button immediately upon perceiving the stimulus. The interval between presentation of the auditory stimulus and the participant’s response was recorded.

For visual simple reaction time, a red light was presented on the display, and the participant was instructed to respond immediately upon detecting the stimulus. The time between presentation of the visual stimulus and the response was recorded. For discriminatory reaction time, the participant was required to differentiate between relevant and irrelevant stimuli and respond only to the predetermined target stimulus. For auditory discriminatory reaction time, beep and tone sounds were presented. The participant was instructed to press the response button when the beep sound was presented and to withhold the response when the tone sound was presented. For visual discriminatory reaction time, red and green lights were presented. The participant was instructed to press the response button when the red light appeared and to withhold the response when the green light appeared. The time between presentation of the target stimulus and the correct response was recorded. For choice reaction time, the participant was required to identify the stimulus and select the corresponding response from two possible responses. For auditory choice reaction time, a beep sound required the participant to press the left button, whereas a tone sound required the participant to press the right button. For visual choice reaction time, a red light required the participant to press the left button, whereas a green light required the participant to press the right button. The time from presentation of the stimulus to the appropriate response was recorded. The test was performed using both hands as required by the reaction-time apparatus. The participant's dominant hand was used for the response, while the non-dominant hand was used for the corresponding operation of the apparatus. This procedure was standardized across participants to minimize variability related to hand dominance and motor response performance. The following outcome measures were recorded separately: simple auditory reaction time, simple visual reaction time, discriminatory auditory reaction time, discriminatory visual reaction time, choice auditory reaction time, and choice visual reaction time. The recorded mean reaction-time values were entered into the statistical analysis and compared between Group A and Group B.

Statistical Analysis

All statistical analyses were performed using appropriate statistical software, with the level of statistical significance set at $p < 0.05$. Continuous variables were summarized using mean ± standard deviation (SD). The normality of continuous outcome variables was assessed using the Shapiro–Wilk test.

Variables demonstrating a normal distribution were analyzed using parametric tests, whereas non-normally distributed variables were analyzed using non-parametric tests. For between-group comparisons of reaction-time outcomes between Group A (T2DM duration 0–5 years) and Group B (T2DM duration >5 years), the independent-samples t-test was used for normally distributed variables, while the Mann–Whitney U test was used for non-normally distributed variables. Within-group comparisons among the three reaction-time conditions—simple, discriminatory, and choice reaction time—were performed separately for auditory and visual stimuli using the Friedman test, as the measurements were obtained from the same participants. Categorical variables, such as gender distribution, were analyzed using the Chi-square test. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 30 participants with Type 2 Diabetes Mellitus were included in the analysis, with 15 participants in each group. Group A consisted of participants with a diabetes duration of 0–5 years, whereas Group B consisted of participants with a diabetes duration of >5 years. The mean age was 57.27 ± 5.63 years in Group 1 and 61.13 ± 6.77 years in Group 2. An independent-samples t-test showed no statistically significant difference in age between the groups ($t = -1.77$, $df = 28$, $p = 0.088$). The mean duration of diabetes was 2.68 ± 1.76 years in Group 1 and 8.87 ± 2.30 years in Group 2. An independent-samples t-test revealed a statistically significant difference in diabetes duration between the groups ($t = -8.28$, $df = 28$, $p < 0.001$).

Variable	Group A (n = 15)	Group B (n = 15)
Age (years), Mean ± SD	57.27 ± 5.63	61.13 ± 6.77
Duration of diabetes (years), Mean ± SD	2.68 ± 1.76	8.87 ± 2.30
BMI (kg/m²), Mean ± SD	24.92 ± 4.23	27.55 ± 4.39

Table 1. Baseline Characteristics of Participants in Groups A and B

The mean BMI was 24.92 ± 4.23 kg/m² in Group 1 and 27.55 ± 4.39 kg/m² in Group 2. An independent-samples t-test showed no statistically significant difference in BMI between the groups ($t = -1.67$, $df = 28$, $p = 0.106$) (Table-1). There was no statistically significant difference in gender distribution between Group A and Group B ($\chi^2 = 0.134$, $p = 0.714$), indicating comparable gender distribution between the groups (Table-2).

Gender	**Group A (n = 15)**	**Group B (n = 15)**	**Statistical Test**	***p*-value**
Female	9 (60.0%)	7 (46.7%)	$\chi^2 = 0.134$	0.714
Male	6 (40.0%)	8 (53.3%)		

Table 2. Gender Distribution of Participants in Groups A and B

Group	**Variable**	**W**	**df**	***p*-value**
A	Simple Auditory	0.920	15	0.191
	Simple Visual	0.883	15	0.052
	Discriminatory Auditory	0.873	15	**0.038**
	Discriminatory Visual	0.850	15	**0.017**
	Choice Auditory	0.955	15	0.607
	Choice Visual	0.939	15	0.372
B	Simple Auditory	0.910	15	0.138
	Simple Visual	0.697	15	**<0.001**
	Discriminatory Auditory	0.861	15	**0.025**
	Discriminatory Visual	0.888	15	0.063
	Choice Auditory	0.904	15	0.109
	Choice Visual	0.838	15	**0.012**

Table 3. Tests of Normality Using the Shapiro–Wilk Test

The Shapiro–Wilk test indicated that simple auditory, simple visual, choice auditory, and choice visual reaction times in Group A were approximately normally distributed ($p > 0.05$). Discriminatory auditory and discriminatory visual reaction times in Group A demonstrated significant deviation from normality ($p < 0.05$). In Group B, simple auditory, discriminatory visual, and choice auditory reaction times were approximately normally distributed, whereas simple visual, discriminatory auditory, and choice visual reaction times demonstrated significant deviation from normality. Accordingly, parametric or non-parametric tests were selected for between-group comparisons based on the distribution of each outcome variable.

Reaction-time variable	**Group A** **Mean ± SD**	**Group B** **Mean ± SD**	**Statistic**	***p*-value**
Simple Auditory	0.627 ± 0.225	0.628 ± 0.263	$t = -0.016$	0.988
Simple Visual	0.517 ± 0.151	0.529 ± 0.364	U = 145.00	0.184
Discriminatory Auditory	0.695 ± 0.198	0.557 ± 0.141	U = 169.00	**0.020**
Discriminatory Visual	0.721 ± 0.288	0.607 ± 0.144	U = 129.00	0.507
Choice Auditory	0.724 ± 0.187	0.662 ± 0.221	$t = 0.832$	0.412
Choice Visual	0.677 ± 0.249	0.618 ± 0.195	U = 135.00	0.361

Table 4. Between-Group Comparison of Reaction Time

No statistically significant difference was observed between Group A and Group B for simple auditory reaction time ($p = 0.988$), simple visual reaction time ($p = 0.184$), discriminatory visual reaction time ($p = 0.507$), choice auditory reaction time ($p = 0.412$), or choice visual reaction time ($p = 0.361$). However, a statistically significant difference was observed in discriminatory auditory reaction time between the two groups ($U = 169.00$, $p = 0.020$). Group A demonstrated a higher mean discriminatory auditory reaction time (0.695 ± 0.198) compared with Group B (0.557 ± 0.141).

Group	Outcome	Friedman χ^2	df	p-value
Group A	Auditory	1.733	2	0.420
Group A	Visual	4.933	2	0.085
Group B	Auditory	6.533	2	**0.038**
Group B	Visual	3.695	2	0.158

Table 5. Within-Group Comparison of Reaction-Time Conditions Using the Friedman Test

The Friedman test demonstrated no statistically significant difference among simple, discriminatory, and choice auditory reaction times in Group A ($\chi^2 = 1.733$, $p = 0.420$). Similarly, no significant difference was observed among the three visual reaction-time conditions in Group A ($\chi^2 = 4.933$, $p = 0.085$). In Group B, a statistically significant overall difference was observed among simple, discriminatory, and choice auditory reaction times ($\chi^2 = 6.533$, $p = 0.038$). However, no statistically significant difference was observed among the three visual reaction-time conditions ($\chi^2 = 3.695$, $p = 0.158$).

DISCUSSION

Reaction time is a complex psychophysiological measure involving stimulus detection, sensory transmission, central information processing, decision-making, and motor response. Both auditory and visual reaction times therefore depend on the integrity of peripheral sensory pathways, central processing mechanisms, attention, and neuromuscular response. Previous studies have reported delayed auditory, visual, and audiovisual reaction times in individuals with T2DM compared with healthy controls [5,6]. Mungal et al. reported significantly higher audiovisual reaction times among patients with T2DM compared with age-matched healthy controls, suggesting that diabetes may adversely affect sensory-motor processing [7]. Similarly, Khode et al. found significantly prolonged simple and choice auditory and visual reaction times in individuals with T2DM compared with controls, with further prolongation during acute mental stress [8]. These findings suggest that T2DM may be associated with altered psychomotor and cognitive processing.

However, these studies primarily compared diabetic individuals with healthy controls, whereas the present study compared two groups within the diabetic population based on disease duration. Therefore, differences between the findings of these studies and the present study may be related to the nature of the comparison. One possible explanation for the absence of a significant difference in the present study is that diabetes duration may not have a simple linear relationship with reaction-time performance. The development of neurological dysfunction in T2DM is influenced not only by the number of years since diagnosis but also by glycemic control, age, age of onset of the disease, metabolic factors, vascular risk factors, neuropathy, medication use, and individual susceptibility. A recent 2025 study by Zaidi and Abdul Samad involving 139 diabetic patients demonstrated a significant association between diabetes duration and slowing of nerve-conduction velocity, as well as between neuropathy severity and nerve-conduction abnormalities. However, the same study also showed that glycemic control was an important factor, with poor glycemic control being common among the participants [9]. Thus, duration alone may not adequately capture the cumulative metabolic and neurological burden of diabetes. Sreenivasan and Kusumadevi studied 60 individuals with T2DM and reported positive correlations between diabetes duration, HbA1c, and visual reaction time, with increasing duration and HbA1c associated with slower visual reaction time [10]. These findings appear different from the present results. However, methodological differences should be considered. Their study examined correlations between continuous measures of disease duration and visual reaction time, whereas the present study categorized participants into two duration groups and assessed audio-visual reaction time. Categorization of a continuous variable can reduce statistical information and may make it more difficult to detect a modest association. Furthermore, the previous study measured HbA1c, whereas HbA1c was not recorded in the present study. Therefore, differences in glycemic control between participants could not be evaluated. Central nervous system involvement may also be relevant. Audio-visual reaction time requires not only peripheral sensory conduction but also central integration of auditory and visual information. Recent reviews describe T2DM-associated cognitive dysfunction as involving domains such as attention, executive function, working memory, and processing speed. A 2025 review specifically reported that cognitive impairment in T2DM is associated with interacting mechanisms involving insulin resistance, chronic inflammation, vascular injury, microangiopathy, and oxidative stress [11].

Excessive oxidative stress can affect neuronal membranes, proteins, DNA, mitochondrial function, and synaptic activity. However, the effects of oxidative stress on functional measures such as reaction time may depend on the degree and duration of metabolic disturbance. These mechanisms could theoretically influence sensory processing and reaction time. Nevertheless, because the present study did not directly evaluate cognition, cerebral perfusion, or central neural processing, these mechanisms cannot be confirmed from the present findings. Medication use and comorbidities may also have influenced the findings. Antidiabetic treatment, hypertension, dyslipidemia, obesity, and other vascular risk factors may modify neurological function and cognitive performance. The present study did not collect detailed information regarding these variables. Therefore, residual confounding cannot be excluded. This is particularly important because diabetes-related neurological dysfunction is not determined solely by disease duration, but by the interaction of metabolic, vascular, inflammatory, and neurodegenerative factors. Overall, the present findings suggest that diabetes duration alone may not be a sufficiently sensitive determinant of audio-visual reaction time. Although T2DM is associated with peripheral neurological dysfunction and cognitive/processing-speed abnormalities in the broader literature, these effects may depend on the severity of hyperglycemia, presence of neuropathy, vascular complications, cognitive status, and other patient-specific factors. Recent evidence continues to support a multifactorial model in which hyperglycemia, oxidative stress, neuroinflammation, mitochondrial dysfunction, and vascular injury interact to influence neurological function rather than acting as isolated mechanisms.

CONCLUSION

The present study did not demonstrate a statistically significant difference in audio-visual reaction time between the two groups. Although previous studies have demonstrated delayed auditory, visual, and audiovisual reaction times in individuals with T2DM, differences in study populations and methodology may explain the variation from the present findings. The relationship between diabetes duration and reaction-time performance is likely multifactorial, involving glycemic control, neuropathy, vascular factors, cognitive function, medication use, and individual susceptibility. Therefore, the absence of a significant difference between the two diabetes-duration groups should not be interpreted as evidence that diabetes has no neurological effect.

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