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ORIGINAL ARTICLE

A case-control study to detect cognitive impairment in Type 2 diabetes mellitus using selected auditory and visual response times under acute mental stress

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ABSTRACT:

Aim: A case-control study to detect cognitive impairment in Type 2 diabetes mellitus using selected auditory and visual response times under acute mental stress. **Methods:** The Department of Physiology conducted this prospective observational research. The research comprised 90 participants between the ages of 35 and 60. Each participant provided informed consent. They were split into two groups. Group 1 consisted of 40 randomly selected diagnosed patients with Type 2 DM with a duration of at least two years. The second group consisted of 45 age and gender-matched controls. The MMSE was used to measure the overall cognitive function of these groups. In these groups, simple and choice auditory and VRTs were evaluated at rest and under acute mental stress to assess cognitive performance. The standard deviation acquired during the pilot research was used to assess the dependability of the response timing. **Results:** The Type 2 DM group had a mean age of 46.33±5.67 years, whereas the control group had a mean age of 44.98±5.73 years. There was a statistically significant difference between weight and BMI. Tables 2 and 3 indicate a substantial difference in ART and VRT in Type 2 DM and controls, both basic and choice. These RTs rose much more under diabetes-related mental stress. There was a significant difference in ART and VRT, both simple and choice, during rest and mental stress, and that these RTs were longer in Type 2 DM as compared to controls. **Conclusion:** We may infer that mental stress in Type 2 DM does influence cognition, with the degree of impairment perhaps correlated with the difficulty of the task (mental stress) and the prevalence of central nerve deficits and peripheral nerve deficits observed as side manifestations of Type 2 DM.

Key words: Cognition; Reaction Time; Mental Stress; Type 2 Diabetes Mellitus

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INTRODUCTION

The prevalence of type 2 diabetes mellitus (T2DM) is rising globally, and it has become a major public health concern. [1] It is linked to death and significant morbidity, including neurological impairment. Although the effects of diabetes on the peripheral nervous system (PNS) are well documented, the consequences on higher mental functions (HMF) are sometimes overlooked owing to a lack of apparent indications and the absence of conventional diagnostic tools. [2,3] Even modest cognitive dysfunction may impede daily tasks, depending on the job and environment, which necessitates a variety of cognitive domains such as general intelligence, processing speed, psychomotor efficiency, attention, perception, learning, memory, and executive functions. [4] Several studies have shown a cognitive decline in T2DM patients. [5,6] However, there is little agreement on the specific areas of cognition that may be altered by T2DM, and hence which domains should be tested. The pace of processing of sensory modalities of stimuli by the central nervous system (CNS) and its achievement by the motor response is indicated by RT, which is a measure of the time required from the commencement of the stimulus to correct response. It has long been assumed that a greater gap between simple RT (SRT) and choice RT (CRT) indicates cognitive impairment. [7] RT assesses cognitive areas such as attention, execution, and psychomotor speed. CRTs are delayed in metabolic syndrome, according to researchers. [8] The goal of this research is to see whether acute emotional stress worsens cognition in people with Type 2 diabetes. The current study's premise is that acute emotional stress causes cognitive impairment in Type 2 diabetes. We measured visual RT (VRT) and auditory RTs (ART), both simple and choice, to assess cognitive function under acute mental stress in Type 2 diabetes patients and compared them to healthy controls who did not have overt cerebrovascular illness or other vascular risk factors.

METHODS AND MATERIALS

After receiving clearance from the protocol review committee and the institutional ethics committee, this prospective observational research was carried out at the Department of Physiology. The research comprised 90 participants between the ages of 35-60. Each participant provided informed consent. They were split into two groups. Group 1 consisted of 45 randomly selected diagnosed cases of Type 2 DM with a duration of at least 2 years. The second group

consisted of 45 age and gender-matched controls. The MMSE was used to assess the overall cognitive function of these groups. In these groups, simple and choice auditory and VRTs were measured at rest and during acute mental stress to assess cognitive function. The standard deviation obtained during the pilot study was used to assess the reliability of the reaction timer. Subjects with hypertension, obesity, smokers, cerebrovascular disorders, cardiovascular, neuropathy, and chronic renal disorders, spine, joint, or bone deformities, and chronic lower back spasm or pain were excluded from the study. A general checkup of pulse, blood pressure, height, weight, and eating habits was performed. Snellen and Jaeger's charts were used for the ophthalmic evaluation.

METHODOLOGY

Following the short instructions, at least three trials of ART and VRT were administered, and the individual RT in milliseconds was recorded. At least three satisfactory recordings were obtained. ART and VRT recordings were deemed repeatable if the difference between the highest and lowest values did not exceed 50 ms. The arithmetic mental challenge generated intense mental stress under time constraints during the process. The participants were instructed to quickly subtract seven from a three- or four-digit value. The participants were urged to complete as quickly as possible during the exam.

Auditory SRT - the participant was instructed to click the correct button when the tone beeped. Auditory CRT - when the tone beeped, the subject was instructed to hit the left button and the right button when the tick beeped. The difference in RT was measured. VSRT - the subject was instructed to hit the correct button as soon as the red light illuminated, and the RT was recorded. VCRT was performed by instructing the participant to push the left button when the green light lights and the right button when the red light glows, and differential RT was recorded.

STATISTICAL ANALYSIS

All calculations were done using SPSS 25.0 statistical software on a desktop PC. The independent t-test was used to compare the means of continuous variables between patients with Type 2 Diabetes and healthy controls. The paired t-test was used to compare the mean RTs of people with Type 2 DM with healthy controls both at rest and during a continuous mental stress condition.

RESULTS

According to Table 1, there was no statistically significant difference in age between patients and controls. The Type 2 DM group had a mean age of 46.33±5.67 years, whereas the control group had a mean age of 44.98±5.73 years. There was a statistically significant difference between weight and BMI. Tables 2 and 3 indicate a substantial difference in ART and VRT in Type 2 DM and controls, both basic and choice. These RTs rose much more under diabetes-related mental stress. Table 4 reveals that there was a significant difference in ART and VRT, both simple and choice, during rest and mental stress, and that these RTs were longer in Type 2 DM as compared to controls.

Table 1: Demographic characters in type 2 diabetes mellitus and controls

Parameter	Diabetes *n*=45	Controls *n*=45	t value	*P* value
Age	46.33±5.67	44.98±5.73	1.21	0.36
Weight	66.71±5.6	61.71±5.96	1.72	0.45
BMI	23.92±1.91	23.85±2.74	0.81	0.51
SBP	122.8±3.64	123.1±3.65	2.64	0.02
DBP	80.2±2.58	80.0±1.74	1.22	0.44

BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

Table 2: Visual and auditory reaction times in type 2 diabetes mellitus and controls during rest

Parameter	Diabetes *n*=45	Controls *n*=45	t value	*P* value
VRTS	419.74±59.85	246.74±3978	9.85	0.000
VRTC	449.89±89.36	281.77±61.78	6.91	0.000
ARTS	351.47±77.91	218±25.85	5.88	0.000
ARTC	382.79±93.68	293.58±55.74	5.78	0.000

S: Simple, C: Choice

Table3: Visual and auditory reaction times in type 2 diabetes mellitus and controls during mental stress

Parameter	Diabetes *n*=45	Controls *n*=45	t value	*P* value
VRTSS	531.78±88.87	291.22±63.37	8.74	0.000
VRTCS	551.74±74.91	321.18±67.84	7.61	0.000
ARTSS	462.83±64.83	302.24±74.25	5.89	0.000
ARTCS	501.22±88.37	342.44±61.57	5.97	0.000

Table 4: Visual and auditory reaction times in type 2 diabetes mellitus and controls during resting and mental stress

Reaction times	Diabetes *n*=45		Controls *n*=45	
VRTS	419.74±59.85	−5.69	246.74±3978	−4.74
VRTSS	531.78±88.87	0.000	291.22±63.37	0.000
VRTC	449.89±89.36	−3.52	281.77±61.78	−3.58
VRTCS	551.74±74.91	0.002	321.18±67.84	0.003
ARTS	351.47±77.91	−7.63	218±25.85	−6.63
ARTSS†	462.83±64.83	0.000	302.24±74.25	0.000
ARTC	382.79±93.68	−5.63	293.58±55.74	−5.57
ARTCS†	501.22±88.37	0.000	342.44±61.57	0.000

DISCUSSION

In this case-control investigation, we found a significant difference in ART and VRT, both simple and choice, in Type 2 DM and controls, and these RTs rose more in Type 2 DM than in controls following mental stress. We discovered a substantial difference in ART and VRT, both simple and choice, when resting and under mental stress, and these RTs were longer in Type 2 DM when compared to controls and need competent personnel to measure. RTs, on the other hand, may be simply documented in an outpatient department. They may be used to detect changes in cognitive function, notably attention and psychomotor speed. As a result, the study's strength was that RTs may be used as a screening tool for early diagnosis of cognitive impairment. Many studies have revealed that Type 2 DM also affects the middle-aged. We did include the younger population in our analysis. Subjection to different types of stress is now a frequent everyday occurrence in the lives of most people, which may influence brain function in either a favourable or bad manner. The length and kind of stressor have a significant impact on the cumulative effect of stress. Stress, in its acute form, may be vital in the adaptive process for survival, causing transitory alterations inside the CNS. In this work, we attempted to evaluate the temporary impact of stress on RT in Type 2 diabetes.

It is critical to recognise and treat cognitive deterioration in Type 2 diabetes as soon as possible. Stress testing reveals cognitive impairment before it manifests itself at rest. There are a variety of tests available to diagnose cognitive impairment in many areas. [9,10] Although most previous studies examining cognitive function in individuals with Type 2 DM, such as the MMSE, focused on global cognitive function or combined measures of several cognitive tests, there is growing evidence in the literature on specific domains of cognitive function and possible distinct association with Type 2 DM. [11,12] Research has focused on identifying various areas that may help to understand the mechanism through which Type 2 DM affects cognitive performance.

The majority of researchers believed that mental dysfunction caused by acute or chronic stress is a very difficult problem in the current situation. Stress is generally damaging, afflictive, and dangerous to one's health. Stress evaluation tools are essential for health researchers, including physicians and psychologists, to investigate the negative impacts of stress. It is possible to detect stress using physiological signs and measurements. However, it may be difficult at times. The laboratory-based tests are very beneficial for collecting a larger number of stress samples. Researchers believe that laboratory-based investigations and experiments are more beneficial for evaluating stress than real-time tests. Various stress-inducing procedures have previously been utilised, including the Stroop color-word test,[13] mental arithmetic task,[14] public speaking task, isometric handgrip test,[15] cold pressor test,[16] and computer work. [17] Mental stress testing is the easiest to perform and may be accurately controlled by the investigator. Although the Mensa exam, Stroop color-word test, and stressful interview are all various ways to induce stress in research, mental arithmetic employing serial subtraction is the most often utilised methodology. A battery of tests is available to detect cognitive impairment in many areas. These neuropsychological examinations need a significant amount of time, qualified personnel, and the participants' participation. VRT is defined as the time elapsed between the display of visual stimuli and the following motor reaction to those stimuli. VRT and ART are thought to be appropriate tools for assessing sensory-motor connection. RT assesses cognition in particular areas such as attention, execution, and psychomotor speed. CRTs are delayed in Type 2 diabetes, according to research.

Our research has one or two drawbacks. Although the controls were age and gender matched, their BMI was not. It is indicated that BMI has an impact on cognition. [18] Another drawback of the research was that we did not conduct a benchmark test to establish a cognitive function against which we could compare our findings and evaluate the sensitivity and specificity of our test. However, these battery tests are time-consuming.

CONCLUSION

Based on the results, it appears that mental stress in Type 2 DM does have an effect on cognition, with the degree of impairment possibly correlated with the inherent challenge of the task (mental stress) and the frequency with which central nerve deficits and peripheral nerve deficits manifest as symptoms of the

disease. With the smallest distance between the brain and the rest of the body occupied by the peripheral nerve system, the simplest activities, such as ART and VRTs, exhibited the least amount of delay in response times. Because of the complexity of the circuits involved, CVRTs will take longer to complete. Results from this research reveal that cognitive function is impaired in people with Type 2 DM, and that mental stress exacerbates this decline.

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