RESEARCH ARTICLE

Detection of cognitive impairment in Type 2 diabetes mellitus by choice auditory and visual reaction times during acute mental stress: A case–control study

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ABSTRACT

Background: Cognitive dysfunction in Type 2 diabetes mellitus (DM) can be unveiled by stress test even before it develops at rest. Mental stress testing is easier to administer and can be precisely regulated by the investigator. Mental arithmetic using serial subtraction is the most widely used method to administer stress. Reaction time (RT) widely used to assess cognitive domains such as attention, execution, and psychomotor speed. Investigators have shown that choice RTs are delayed in Type 2 DM. **Aim and Objectives:** The objective of the present study was to assess cognitive dysfunction in Type 2 DM during acute mental stress without overt cerebrovascular disease or other vascular risk factors. **Materials and Methods:** After getting medical ethical clearance of our institution, 60 subjects between the given age group (35–55 years) were enlisted in the study. They were categorized into two groups. Group 1 had 30 diagnosed cases of Type 2 DM at least 2 years of duration. Group 2 had 30 gender and age-matched controls. Mini-mental status examination was performed to assess global cognitive function in these groups. Simple and choice auditory and visual RTs (VRTs) were measured during rest and during acute mental stress in these groups to assess cognitive function. **Results:** There was a significant difference in auditory RT and VRT, both simple and choice in Type 2 DM and controls and these RTs further increased during mental stress ($P < 0.001$). **Conclusion:** Cognitive function in Type 2 DM deteriorates with acute mental stress.

KEY WORDS: Cognition; Reaction Time; Mental Stress; Type 2 Diabetes Mellitus

INTRODUCTION

Type 2 diabetes mellitus (DM) is a commonly occurring condition in the elderly and has been associated with central and peripheral neuronal degeneration which causes cognitive impairment, dementia,[1,2] and peripheral neuropathy. All of these cause delays in reaction times (RTs). Investigators have shown that choice RTs which are one of the indicators of cognition that is delayed in diabetes.[3,4]

Stress testing unveils cognitive dysfunction even before it develops at rest. Mental stress testing is easier to administer and can be precisely regulated by the evaluator. Although Stroop color-word test, Mensa test stressful interview are different methods of inducing stress used in studies, mental arithmetic using serial subtraction is the most widely used method.[5] There are batteries of tests available to detect cognitive dysfunction affecting different domains. The majority of studies examining cognitive function in individuals with Type 2 DM such as the mini-mental status examination (MMSE) have focused on global cognitive outcomes or compound measures of several cognitive tests.

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There is growing evidence in the literature on specific domains of cognitive function and possible distinctive association with Type 2 DM. Recent studies have focused on identifying and pinpointing specific domains which may contribute in the impairment of cognitive function in Type 2 DM.[6,7]

RT is a measure of the time taken from the onset of the stimulus to proper response which is an indicator of the rate of processing of sensory modes of stimuli by the central nervous system (CNS) and its accomplishment by the motor response. It is established that an increased difference between simple RT (SRT) and choice RT (CRT) implies cognitive dysfunction.[8] RT measures different domains of cognition such as attention, execution, and psychomotor speed. Investigators have shown that CRTs are delayed in metabolic syndrome.[9]

The intension of this study is whether acute mental stress further deteriorates cognition in Type 2 DM. The hypothesis of the present study is that acute mental stress induces cognitive dysfunction in Type 2 DM. We recorded visual RT (VRT) and auditory RTs (ART) both simple and choice, therefore cognitive performance during acute mental stress in Type 2 DM and compared with healthy controls without overt cerebrovascular disease or other vascular risk factors.

MATERIALS AND METHODS

After getting medical ethical clearance of our institution, 60 subjects within the age group of 35–55 years were included in the study. Informed consent was taken by each subject. They were cleaved into two groups. Group 1 comprised of randomly chosen 30 diagnosed cases of Type 2 DM at least 2 years of duration. Group 2 comprised of 30 age and gender-matched controls. MMSE was performed to assess the global cognitive function in these groups. Simple and choice auditory and VRTs were measured at rest and acute mental stress in these groups to assess cognitive function. The reliability of the reaction timer was tested by standard deviation obtained during the pilot study.

Exclusion Criteria

The following criteria were excluded from the study: Hypertensives, obese, smokers, cerebrovascular disorders, cardiovascular, neuropathy, and chronic renal disorders, deformities of the spine, joints or bones, and chronic lower back spasm or pain. General checkup of pulse, blood pressure, height, weight, food habits were recorded. The ophthalmic evaluation was performed using Snellen and Jaeger's chart.

Procedure

After the brief instructions, at least three trials for each of ART and VRT were given and the individual RT in milliseconds was recorded. An effort was made to get at least three acceptable recordings. Recordings of the ART and VRT were considered reproducible unless the difference between the highest and lowest values did not exceed 50 ms. During the procedure, acute mental stress was induced under time pressure by the arithmetic mental challenge. The subjects were asked to rapidly subtract seven from a three- or four-digit number. Throughout the test, investigators encouraged the subjects to perform as fast as possible.

Auditory SRT – the subject was directed to press the right button as soon as tone beeps. Auditory CRT – the subject was directed to press the left button when tone beeps and right button when tick beeps. The differential RT was recorded. VSRT – the subject was directed to press the right button as soon as red light glows and RT was recorded. VCRT – the subject was instructed to press the left button when green light glows and the right button when red light glows and differential RT was recorded.

Statistical Analysis

All analyses were performed on a personal computer with the assistance of SPSS 20 statistical software (2012). Differences in mean values for continuous variables in Type 2 DM and controls were tested with independent t-test. Differences in mean values of RTs during resting and mental stress continuous in Type 2 DM and controls were tested with paired t-test.

RESULTS

As per Table 1, there was no significant difference in age in cases and controls. The mean age of Type 2 DM group was 46.8 years and the control group was 44.7 years. There was a significant statistical difference between weight and BMI. Tables 2 and 3 show a significant difference in ART and VRT, both simple and choice in Type 2 DM and controls. These RTs further increased during mental stress in diabetes. Table 4 shows that there was significant difference ART and VRT, both simple and choice during resting and during mental stress and these RTs were more prolonged in Type 2 DM when compared to controls.

DISCUSSION

In this case-control study, we observed that there was a significant difference in ART and VRT, both simple and choice in Type 2 DM and controls and these RTs further increased during mental stress in Type 2 DM than in controls. We observed there was significant difference ART and VRT both simple and choice during resting and during mental stress and these RTs were more prolonged in Type 2 DM when compared to controls.

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

Variables	Diabetes *n*=30	Controls *n*=30	t value	*P* value
Age	46.8±4.3	44.7±5.6	1.162	0.108
Weight	66.0±8.7	62.4±9.4	1.551	0.126
BMI	22.8±2.6	22.2±2.8	0.835	0.407
SBP	124.7±5.1	121.8±4	2.491	0.016
DBP	80.2±4.3	79.3±2.2	1.011	0.316

*P<0.05, BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

Table 2: Visual (V) and auditory (A) reaction times in type 2 diabetes mellitus and controls at rest

Variables	Diabetes *n*=30	Controls *n*=30	t value	*P* value
VRTS	419.4±74.2	243.2±46.2	11.038	0.000*
VRTC	451.6±98.2	275.4±49.6	8.764	0.000*
ARTS	346.3±81.5	215±43	7.761	0.000*
ARTC	378.5±104.7	289±60.3	4.055	0.000*

*P<0.05, S: Simple, C: Choice

Table 3: Visual (V) and auditory (A) reaction times in type 2 diabetes mellitus and controls during mental stress

Variables	Diabetes *n*=30	Controls *n*=30	t value	*P* value
VRTSS[†]	523.4±105.8	287.3±55.7	10.804	0.000*
VRTCS[†]	546.6±115.4	316.9±81.3	8.914	0.000*
ARTSS[†]	459.5±96.7	299.1±93.2	6.539	0.000*
ARTCS[†]	497.4±119.2	339.7±55.9	6.558	0.000*

*P<0.05, S: Simple, C: Choice, S[†]: Mental stress

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

Reaction times	Diabetes *n*=30		Controls *n*=30	
VRTS	419.4±74.2	−6.456	243.2±46.2	−4.876
VRTSS[†]	523.4±105.8	0.000	287.3±55.7	0.000
VRTC	451.6±98.2	−3.660	275.4±49.6	−3.357
VRTCS[†]	546.8±115.4	0.001	316.9±81.3	0.002
ARTS	346.3±81.5	−7.625	215±43.9	−6.684
ARTSS[†]	459.5±96.7	0.000	299.1±93.2	0.000
ARTC	378.5±104.7	−5.619	289±60.3	−5.529
ARTCS[†]	497.4±119.2	0.000	339.7±55.9	0.000

*P<0.05, S: Simple, C: Choice, S[†]: Mental stress

Many studies have shown Type 2 DM even affects middle-aged too. In our study, we did involve the younger population. Subjection to various forms of stress is a common daily observation in the living of most individuals now, which can affect brain function in a positive way or negative way. The cumulative effect of stress is strongly influenced by the duration and type of stressor. In the acute form, stress may be essential in the adaptive mechanism for survival and leads to transient changes within the CNS. In our study, we tried to assess the transient effect on RT in Type 2 DM as a secondary effect of stress on cognition.

It is important to detect cognitive dysfunction in Type 2 DM early and treat. Stress testing unveils cognitive dysfunction even before it develops at rest. There are batteries of tests available to detect cognitive dysfunction affecting different domains.[10,11] Although the most of the earlier studies examining cognitive function in individuals with Type 2 DM such as the MMSE have 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 distinctive association with Type 2 DM.[12,13] Studies have focused on recognizing specific domains which may contribute to identifying the mechanism by which Type 2 DM impairs cognitive function.

The majority group of researchers has agreed that mental dysfunction due to acute or chronic stress is a highly challenging issue in the present scenario. In general, stress is harmful, afflictive, and hazardous to health. Stress assessing instruments play an important role for health researchers among the doctors and psychologist to examine the deleterious effects of stress. Detecting the stress from the physiological signals and parameters is reliable. However, sometimes it is challenging. The laboratory-based experiments are highly useful to achieve more number of stress samples. Researchers consider relying on laboratory-based investigations and experiments for assessing the stress more useful than real-time experiments. There are different stress-inducing techniques which have been used previously such as Stroop color-word test,[14] mental arithmetic task,[15] public speaking task, isometric handgrip test,[16] cold pressor test,[17] and computer work.[18] Among all, mental stress testing is easier to administer and can be precisely regulated by the investigator. Although Mensa test, Stroop color-word test, and stressful interview are different methods of inducing stress used in studies, mental arithmetic using serial subtraction is the most widely used technique. There are series of tests available to identify cognitive dysfunction affecting different domains. These neuropsychological tests require a lot of time, trained staff, and cooperation of the subjects. VRT is the time between the presentation of visual stimuli and subsequent motor response to stimuli. VRT and ART are considered as a suitable tool for measuring sensory-motor association. RT measures specific domains of cognition such as attention, execution, and psychomotor speed. Investigators have shown that CRTs are delayed in Type 2 DM.

There are one or two limitations of our study. Although controls were age- and gender-matched, their BMI differed. It is implied that BMI affects cognition.[19] Another limitation of the study was that we did not perform the benchmark test that could identify a cognitive function where we could contrast our observation and assess the sensitivity and specificity of our test. However, these batteries of tests are time-devouring

and require skilled individuals to assess. On the other side, RTs can be easily recorded on an outpatient department basis. They can prove sensitive indicators of cognitive function, particularly attention and psychomotor speed. Therefore, the strength of this study was that RTs can be a screening tool for early detection of cognitive dysfunction.

CONCLUSION

From this study, we can conclude that mental stress in Type 2 DM does affect cognition, where grades of deterioration may be related to the difficulty of the given task (mental stress) and prevalence of central nerve deficits and peripheral nerve deficits seen as side-manifestation of Type 2 DM. Simple ART, VRTs, the simplest of tasks with the shortest path between the peripheral nervous system and CNS showed less delayed RTs. CVRTs will be more delayed because of the involvement of complicated circuits. The findings of this study suggest that cognition is affected in Type 2 DM patients and mental stress further deteriorates cognition.

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