

A Case Control Study Assessing Cognitive Performance during Acute Mental Stress in Type 2 DM Patients

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Abstract

Aim: 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.

Material & Methods: The present study was conducted in the Department of Physiology, Patna medical college and Hospital, Patna, Bihar, India for five months, 100 subjects within the age group of 30–55 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 50 diagnosed cases of Type 2 DM at least 2 years of duration. Group 2 comprised of 50 age and gender-matched controls.

Results: There was no significant difference in age in cases and controls. The mean age of Type 2 DM group was 47.3 years and the control group was 45.5 years. There was a significant statistical difference between weight and BMI. The result showed a significant difference in ART and VRT, both simple and choice in Type 2 DM and controls. 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.

Conclusion: The present study concluded 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.

Keywords: Cognition; Reaction Time; Mental Stress; Type 2 Diabetes Mellitus.

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Introduction

Diabetes Mellitus is a complex metabolic disease that can have devastating effects on multiple organs in the body. Diabetes is the leading cause of end stage renal disease [1] and is also a common cause of vision loss, neuropathy, and cardiovascular disease. A less addressed and not as well recognized complication of diabetes is cognitive dysfunction. It is a commonly occurring condition in the elderly and has been associated with central and peripheral neuronal degeneration which causes cognitive impairment, dementia, [2,3] and peripheral neuropathy. Patients with type 1 and type 2 diabetes mellitus have been found to have cognitive deficits that can be attributed to their disease. Both hypoglycemia and hyperglycemia have been implicated as causes of cognitive dysfunction, and many patients fear that recurrent hypoglycemia will impair their memory over time.

Over the past several years, evidence that showed impairment in brain insulin and Insulin-like Growth Factor (IGF) signaling, mediates cognitive

impairment and neuro-degeneration has developed particularly in relation to mild cognitive impairment and Alzheimer disease (AD). [4] The most common cognitive deficits identified in patients with type 1 diabetes are slowing of information processing speed and worsening psychomotor efficiency. [5] Type-2 diabetes has been associated with a decrease in psychomotor speed, frontal lobe/executive function, [6] complex motor functioning, verbal fluency, [7] verbal memory, processing speed, [8] working memory, immediate recall, delayed recall, visual retention and attention. [9] Chronic hyperglycemia, increased duration of diabetes and the increasing age of the patients are the three important factors influencing the impairment of cognitive dysfunction in diabetics. [10]

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. [11]

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. [12] RT measures different domains of cognition such as attention, execution, and psychomotor speed. Investigators have shown that CRTs are delayed in metabolic syndrome. [13]

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. Visual RT (VRT) and auditory RTs (ART) both simple and choice were recorded, 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.

Material & Methods

The present study was conducted in the Department of Physiology, Patna medical college and Hospital, Patna, Bihar, India for five months, 100 subjects within the age group of 30–55 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 50 diagnosed cases of Type 2 DM at least 2 years of duration.

Group 2 comprised of 50 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.

Procedure

General check-up of pulse, blood pressure, height, weight, food habits were recorded. The ophthalmic evaluation was performed using Snellen and Jaeger's chart. 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

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

Variables	Diabetes n=50	Controls n=50	P value
Age	47.3±4.7	45.5±5.5	0.112
Weight	67.0±8.2	63.7±9.1	0.122
BMI	23.7±2.8	24.6±2.8	0.422
SBP	122.8±5.4	120.8±6	0.018
DBP	79.1±4.3	78.2±2.2	0.316

There was no significant difference in age in cases and controls. The mean age of Type 2 DM group was 47.3 years and the control group was 45.5 years. There was a significant statistical difference between weight and BMI.

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

Variables	Diabetes n=50	Controls n=50	P value
VRTS	422.8±72.8	246.4±47.3	0.000
VRTC	455.5±98.2	280.4±44.6	0.000
ARTS	350.5±85.5	220±40	0.000
ARTC	382.8±102.8	294±62.8	0.000

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

Variables	Diabetes n=50	Controls n=50	P value
VRTSS [†]	525.5±102.8	285.5±55.5	0.000
VRTCS [†]	540.4±116.4	316.4±82.8	0.000
ARTSS [†]	452.8±96.4	294.6±96.4	0.000
ARTCS [†]	494.6±116.4	332.8±51.9	0.000

Tables 2 and 3 showed a significant difference in ART and VRT, both simple and choice in Type 2 DM and controls. 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

Various diseases, many neurological and metabolic, are known to affect RT in individuals. [14,15,16,17] Individuals with schizophrenia show a substantial impairment in overall cognitive performance, which, on average, is around two standard deviations below that in healthy controls. [18] Diabetes mellitus is a metabolic disease which manifests neurological complications. There are various cognitive domains which could be affected in diabetes, and with the high prevalence, a large population of the world could face cognitive challenges in daily life. Various mechanisms have been proposed to explain the neurological changes in diabetes mellitus. On the basis of anatomical distribution Dyck et al. Proposed that microvascular injury in diabetes could be damaging the nerves. [19] Later other possible mechanism were proposed mainly oxidative stress, inflammatory activity. [20]

There was no significant difference in age in cases and controls. The mean age of Type 2 DM group was 47.3 years and the control group was 45.5 years. There was a significant statistical difference between weight and BMI. The result showed a significant difference in ART and VRT, both simple and choice in Type 2 DM and controls. 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. 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. [21,22]

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. [23,24] Studies have focused on recognizing specific domains which may contribute to identifying the mechanism by which Type 2 DM impairs cognitive function.

When people engage in protracted periods of intensive cognitive activity that call for continuous mental efficiency, their psycho-physiological state, known as mental stress, alters. [25,26] We experience stress every day, which is harmful, afflictive, and hazardous to health. A majority group of researchers has agreed that mental dysfunction due to acute or chronic stress is a highly challenging issue in the present scenario. There is an adverse impact of stress on cognitive performance. [26,27,28,29]

It is difficult to create social or real life conditions of stress in laboratory. [26,30] Majority of the laboratory conditions focus on acute stress.. A supplemental task could be added to the primary task to induce stress. These supplemental activities can have a negative impact on the execution of the primary task and are frequently perceived by subjects as stressful, although with enough practice people can adapt. It is easy to induce stress using this methodology and are employed by researchers frequently. [30,31] 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 a widely used technique. Among all, mental stress testing is easier to administer and can be precisely regulated by the investigator. Questionnaire based assessment, interview or physiological testing could be used to assess stress. Here in our study we used a mental arithmetic task to induce the element of stress.

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. Similar studies published previously by different authors have shown increased reaction time to different parameters in patients of diabetes mellitus. [32,33,34] This is in line with our study. Various other factors that have influence on cognitive functions such as gender, fatigue, distraction, practice effects etc. Should also be thought of as confounders and included in study design. Although various mechanism for such changes have been proposed, these changes may be due to a combination of different mechanism. In future, studies could be done involving larger sample sizes and different domains of cognition to understand better the mechanism of changes.

Conclusion

The present study concluded 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 suggested that cognition is affected in Type 2 DM patients and mental stress further deteriorates cognition.

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Abbreviations

VRTS: Visual Reaction Time Simple

VRTC: Visual Reaction Time Choice

ARTS: Auditory Reaction Time Simple

ARTC: Auditory Reaction Time Choice

VRTSS: Visual Reaction Time Simple During Stress

VRTCS: Visual Reaction Time Choice During Stress

ARTSS: Auditory Reaction Time Simple During Stress

ARTCS: Auditory Reaction Time Choice During Stress

MMSE: Mini-Mental State Examination

SBP: Systolic Blood Pressure

DBP: Diastolic Blood Pressure