Assessment of attention concentration and memory in patients with type 2 diabetes mellitus

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ABSTRACT

Introduction and Aim: The evidence for attention concentration and memory deficits in patients with type-2 diabetes mellitus has been inconsistent. In India, very few studies have evaluated memory in the patients with type 2 diabetes mellitus. We aimed to compare the attention concentration and memory between diabetics and non-diabetics.

Materials and Methods: This cross-sectional study involved 124 type-2 diabetic patients attending the diabetology outpatient department of SRM Medical college hospital and research centre aged between 30 and 60 years and 124 age-matched non-diabetic subjects as controls. Subjects with psychiatric illness, liver dysfunction, thyroid disorder, type I diabetes mellitus, hypertension, history of previous head injury, stroke, epilepsy *etc.* were excluded from the study. After history taking and clinical examination, glycosylated haemoglobin (HbA1c), fasting blood sugar (FBS) and postprandial blood sugar (PPBS) levels were tested. We excluded the subjects with subpsychiatric illness by using General Health questionnaire. Folstein mini mental state examination (MMSE) evaluated the cognition of the subjects and the PGI memory scale was used to investigate attention concentration and memory in all the subjects.

Results: We found that the MMSE score, attention concentration and retention for dissimilar pairs were significantly decreased among diabetics when compared to non-diabetics. The recent memory, remote memory and recognition have a negative correlation with duration of type-2 diabetes mellitus. MMSE score, attention concentration and retention for dissimilar pairs have a negative correlation with FBS, PPBS & HbA1c. Mental balance for type-2 diabetes is negatively correlated to FBS & HbA1c and immediate recall has a negative correlation with FBS.

Conclusion: Our study results indicate that attention concentration and memory were impaired in type-2 diabetic patients in comparison with the controls and most of the memory subsets of type-2 diabetes mellitus patients have a negative correlation with blood sugar levels.

Keywords: Attention concentration; Type-2 diabetes mellitus; Memory.

INTRODUCTION

Diabetes has become a major health care problem in India with an estimated 66.8 million people suffering from the condition, representing the largest number of any country in the world (1). Type-2 diabetes appears to be associated with an increased risk of cognitive dysfunction in a wide array of cognitive tests and have detrimental effects on cognitive functioning (measures of verbal and numerical reasoning, attention, concentration, verbal and visual memory, and verbal fluency) and may increase the risk of dementia (2). These findings were also borne out in larger epidemiological studies (3).

Memory is one of the most important cognitive domains with respect to everyday function and is the process of storing, encoding, and retrieving information. Different forms of memory are recognized, including sensory, short-term, long-term, and working memory (4). In sensory memory, representations of the physical features of a stimulus are stored for a very brief time (1 second), and it is difficult to distinguish from the process of perception. It seems that the principal function of sensory memory is to retain information for a period of time sufficient to allow its transfer to short-term memory. Short-term memory refers to the function that temporarily retains stimuli that have just been perceived. Its capacity is limited in terms of the number of items that can be stored and lasts for 20seconds. Through repetition, information may be transferred from short-term memory to long-term memory. Long-term memory refers to information that is represented on a more permanent basis.

Working memory is a short-term memory system that allows concurrent retention and manipulation of information (5). It is used for thinking about what is already known and for deriving conclusions on the basis of that knowledge; therefore, working memory is fundamental to successful completion of many activities. It is essential for the calculation of mental arithmetic and allows spatial relations to be updated in our mental map as we move through a new geographical location. Earlier studies show that working memory tests are known to activate

structures in the parietal and temporal lobes and in the prefrontal cortex of humans (6).

According to some studies memory and mental processing speed are the cognitive domains most often compromised, whereas other cognitive skills for example attention, problem-solving, and general intelligence tend to be unaffected (7-9).

In those studies that examined memory, loss of verbal working memory was most consistently associated with diabetes however; this presumed association has recently been disputed (10). Whether cognitive deterioration is a direct consequence of chronically elevated blood glucose levels and HBA1C levels has not yet been determined (11-13).

If chronically elevated glucose levels are linked to poorer cognitive performance, one might predict that efforts to improve glycemic control would ameliorate cognitive function or attenuate its decline. There is only limited support for that possibility. So in this study we examined attention concentration and memory, as measured by performance in PGI memory scale in type 2 diabetes patients and age-matched non-diabetic subjects as controls.

MATERIALS AND METHODS

124 patients with Type 2 diabetes (Group 1) of age 30 to 60 years and 124 age and sex matched normoglycemic individuals (Group 2) as controls, attending the Diabetic outpatient department, SRM Medical college Hospital and Research Centre were included in this cross sectional study. Patients with psychiatric illness, liver dysfunction, thyroid disorder, type I diabetes mellitus, hypertension, history of previous head injury, stroke, epilepsy etc. were excluded from the study.

Institutional ethical committee approval was obtained and informed written consent was obtained from all the included study subjects. The diagnosis of Type 2 diabetes mellitus was determined according to WHO criteria, fasting blood sugar ≥126 mg/dl and 2 hour post load glucose test ≥200 mg/dl. Blood glucose levels were estimated by Glucose Oxidase-Peroxidase GOD/POD method using Beckman Coulter auto-analyzer.

All the participants were subjected to a structured interview in the out-patient department to collect demographic information such as age, sex, literacy level and occupation. Other details such as duration of diabetes, presence of co-morbidities such as hypertension, dyslipidemia, personal details such as smoking, alcoholism and treatment were recorded.

Cognitive function tests

The cognition was assessed by Folstein Mini Mental State examination (MMSE). The MMSE test scoring is for total 30 points, and impairment is identified in an individual with a score of below 24. MMSE has overall sensitivity 64% and specificity 96%. We found that the mean MMSE score was significantly decreased among diabetics when compared to non-diabetics. Also, the mean MMSE score was significantly decreased in diabetics with HbA1c levels >7%.

All participants were administered the PGI Memory Scale (14) which consists of 10 subtests standardised for adult subjects. The test for remote memory comprises of simple questions relating to personal and current information. In tests for recent memory questions were asked that assess the patient's ability to recall information and events in the recent past. The test for mental balance gives an idea of balance over one's mental functioning. The learned materials (alphabet and numbers) were recalled in backward and forward series. The time required to complete the recitation was noted precisely with the help of stop watch. Attention and concentration was evaluated by the test of digit span forward and backward repetition.

Digits were read out a steady rate of one digit per second. The test was started with the set of lowest length of digits. For testing delayed recall the investigator reads out the names of common objects (two series of five each) at a uniform interval. The patient was instructed to recall the same after one minute and score of correct recall recorded. The test for immediate recall included sequential reproduction of the sentence in verbatim. Patient was asked to recall the sentences immediately. For testing the verbal retention for similar pairs, a series of similar associative pairs of words (five noun-noun pairs) were administered to the patient. Patient was asked to mention the associate words in response to the stimulus word. In the test for verbal retention for dissimilar pairs, the associate pair of words was unrelated and dissimilar (five noun adjective pairs) and read at a rate of 2 seconds per pair.

For visual retention test, the investigator displayed five cards containing geometrical figure and patient was instructed to reproduce the drawing from memory. For testing recognition the investigator showed a card containing common objects. Two minutes later a second card containing another set of pictures having some picture appeared in first card was shown to the patient. Patient was asked to identify and name the picture that appeared in both the cards. Correct responses were recorded and scores allotted accordingly. The raw score of each subject was noted and then according to the education of the subjects his score was rated.

Statistical analysis

Statistical analysis was done using SPSS version 17.0. The data were expressed as mean ± standard deviation. Descriptive tables were generated, student 't' test and Pearson's correlation was used to

demonstrate the findings. p value of less than 0.05 was considered to be statistically significant.

RESULTS

Table 1: Comparison of physical characteristics between diabetics and controls

Parameters	Group1 (Diabetics) Mean+SD	Group II (controls) Mean+SD	P value
Age in Years	51 ±7.8	50 ±5.6	0.231
Height	154±8.2	159±7.2	0.516
Weight	63.48 ± 8.4	61.12 ± 8.7	0.10
BMI	26.72 ±3.78	25.76±4.23	0.273

SD- Standard deviation; BMI- Body mass index

Table 2: MMSE score and memory test of the study groups by PGI BBD

Parameters	Diabetes (n=124) Mean ± SD	Controls (n=124) Mean ± SD	p value
MMSE	27.16 ± 2.706	28.29 ±2.083	<0.001*
Remote memory	6.00 ± 0.312	6.00 ± 0.02	1.000
Recent memory	5.03 ±.402	5.00 ± 0.04	0.372
Mental balance	6.68 ± 2.336	7.15 ± 1.631	0.069
Attention/Concentration	7.44 ± 1.717	8.56 ± 1.818	<0.001*
Delayed recall	8.02 ± 1.608	8.13 ± 1.331	0.548
Immediate recall	8.71 ± 2.226	8.42 ± 2.416	0.326
Retention (similar)	4.40 ± .945	4.45 ± .736	0.653
Retention (dissimilar)	11.27 ± 3.341	12.60 ± 2.060	<0.001*
Visual retention	6.74 ± 3.880	7.26 ± 2.924	0.238
Recognition	9.35 ± .867	9.47 ± 2.1632	0.590

*P < 0.05 indicates statistical significance

There was a significant variation between the diabetics and the controls in the MMSE score, attention concentration and retention for dissimilar pairs.

Table 3: Correlation of memory with FBS, PPBS, HbA1c and diabetes duration

Parameters		FBS	PPBS	HbA1c	DM duration
MMSE	r value	-0.369	-0.402	-0.441	-0.119
	P value	0.00	0.00	0.00	0.188
Remote memory	r- value	-0.066	-0.062	-0.018	-0.268**
	p value	0.303	0.328	0.774	0.003*
Recent memory	r value	-0.114	-0.026	-0.003	-0.246**
	p value	0.074	0.681	0.958	0.006*
Mental balance	r value	-0.257**	-0.122	-0.143**	0.008
	p value	0.000*	0.055	0.025*	0.928
Attention/Concentration	r value	-0.339**	-0.356**	-0.366**	0.019
	p value	0.00*	0.00*	0.00*	0.837
Delayed recall	r value	-0.056	-0.160*	-0.130*	-0.122
	p value	0.381	0.012*	0.041*	0.176
Immediate recall	r value	-0.130**	-0.051	-0.012	0.049
	p value	0.040*	0.420	0.857	0.592
Retention (similar)	r value	0.032	-0.116	-0.097	0.158
	p value	0.611	0.068	0.127	0.079
Retention (dissimilar)	r value	-0.235**	-0.318**	-0.313**	0.068
	p value	0.00*	0.00*	0.00*	0.455
Visual retention	r value	-0.092	-0.196**	-0.197**	-0.079
	p value	0.149	0.002*	0.002*	0.382
Recognition	r value	-0.091	-0.069	-0.080	-0.223*
	p value	0.155	0.280	0.208	0.013

*P < 0.05 indicates statistical significance: ** r-value shows significant correlation

The table shows that recent memory, remote memory and recognition have a negative correlation with diabetic duration. MMSE score, attention, concentration and retention for dissimilar pairs have a negative correlation with FBS, PPBS & HbA1c. Delayed recall and visual retention are negatively correlated with PPBS & HbA1c. Mental balancing is

negatively correlated to FBS & HbA1c and immediate recall has a negative correlation with FBS.

DISCUSSION

The present study has demonstrated that in adults with type-2 diabetes, there is a significant reduction in the mean MMSE score of the diabetics when compared to the controls akin (15) to the research of Eze *et al*. Table 1 show that both the groups were comparable. There is a significant negative correlation between MMSE score and fasting, postprandial blood sugar levels and HbA1c (16) as shown in Table 2, which is in concordance with the results of Ebady *et al*.

On the contrary, Lindeman *et al*., compared participants having diabetes and those with normal glucose tolerance and their results did not demonstrate any cognitive impairment in diabetes after adjusting the factors like ethnic background, gender, age, literacy level and depression (17).

We found the recent memory, remote memory and recognition scores were significantly reduced with increase in the duration of diabetes as shown in Table 3. There is negative correlation between mental balance and the HbA1c and FBS, negative correlation between delayed recall, visual retention scores, post prandial blood sugar and HbA1c.

The participants of the study were evaluated extensively on ten different aspects of cognition with the help of PGI memory scale. Cognitive assessment revealed impairment on attention / concentration and verbal retention (dissimilar pairs) which tests the capability of acquiring new info. Recent memory (capability to keep in mind comparatively new info), remote memory (capability to recall past events), mental balance (order of events), and delayed recall (short duration memory), retention of similar pairs (capability to learn simple things), visual retention (capability of processing and understanding visual info), recognition *etc*. were in comparison with the controls as shown in table 4.

If diabetic patients typically experience chronically elevated blood glucose levels, and if this adversely affects the availability and/or utilization of glucose within the brain, then individuals with poorer metabolic control might have more difficulty performing cognitively demanding tasks, pre-dominantly those like working memory tasks, which engage multiple cortical regions of the brain.

It is plausible that improvements that are reduction in peripheral blood glucose levels may lead to a corresponding increase in brain glucose availability as well as relative improvements in performance on certain cognitive tasks.

CONCLUSION

The results of the present study have clearly demonstrated the detrimental effects of diabetes on memory. Our results have shown that many individuals with type-2 diabetes are subject to substantial impairments of memory function in their everyday lives, which may have essential practical implication for daily activities, including effective working ability. Having a good control of blood glucose level in subjects with type-2 diabetes mellitus will reduce these sequelae.

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