

## Working & Short Term Memory Status in Type 2 Diabetes Mellitus

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### ABSTRACT

**Background and objectives:** Working and short term memory loss is common in elderly and poorly controlled diabetic patients. Though cognitive deficits affect daily activities much importance is not given to assess working and short term memory at bedside. Hence this study was undertaken to compare working and short term memory in type 2 diabetics with age and gender matched normal subjects.

**Methodology:** Present study was conducted in Al-Ameen Medical College and Government district Hospital, Bijapur on 114 diabetics and 119 normal subjects aged (40-60 yrs.). Cognitive function assessment was done for short term and working memory by using 5 memory tests-AVLT, VFT, VRT, WDST and VST were used. The results were expressed in average total scores (%).  $\chi^2$  test was used for statistical analysis.

**Results:** Significant decrease in working and short term memory was observed in diabetic patients. Among diabetics elderly aged (> 55yrs) showed greater cognitive decline compared to younger age group. Cognitive decline was observed in both diabetic males & diabetic females.

**Interpretation and Conclusion:** The short term and working memory status in the present study decreased significantly in the diabetic patients, which may be due to hyperglycemia, hypoglycemia, vascular dementia and insulin resistance, type of diabetes, age of onset, duration and type of therapy. Therefore these observed effects of age & gender are of potential clinical importance because working and short term memory loss could interfere with day today activities.

**Keywords:** short term & working memory, Diabetes, hyperglycemia, hypoglycemia

### INTRODUCTION

Memory is one of the most important cognitive domains with respect to every day function & is the process of storing, encoding & retrieving information. Different forms of memory are recognized including short term, long term & working memory.

Short term memory refers to the function that temporarily retains stimuli that have just been perceived and lasts for ~20 secs. Working memory is a short term memory system that allows concurrent retention & manipulation. It is used for thinking about

what is an already known & deriving conclusion on the basis of that knowledge.<sup>[1]</sup>

Some cross sectional studies suggest that hypoglycemia, hyperglycemia, hyperinsulinemia & vasculopathy in DM lead to decline in cognitive function. Studies of cognitive function among older persons might focus on the areas of cognition most affected by common dementing illness, including memory, attention, language, visuospatial ability & abstraction.<sup>[2]</sup>

Several studies have reported significant cognitive impairment among subjects with DM compared with non DM individuals. Hence this study is undertaken to assess impairment in Working and Short term memory in type 2 diabetes patients in comparison with age and gender matched normal subjects in Indian population.

## MATERIALS AND METHODS

## RESULTS AND DISCUSSION

The present study was conducted in the department of physiology Al-Ameen Medical College Bijapur.

One Hundred and fourteen (114) diabetic patients between 40-60 years of age visiting to the Al-Ameen Medical college Hospital Bijapur (Karnataka), District civil hospital Bijapur & Monthly diabetic camps were volunteers for this study. One hundred and nineteen (119) normal subjects (control group) age & Gender matched near hospital premises and from Bijapur city were volunteers for this study.

Different memory tests were used to assess short term and working memory. Short term memory tests used were: Auditory verbal learning test, Visual reproduction test & Verbal fluency test. Working memory tests used were: Working digit span test & Validation span test<sup>[3,1]</sup> Data was analyzed using  $\chi^2$  test.

TABLE.NO.1:  $\chi^2$  & P values of chi-square test of memory tests of normal subjects & type 2 diabetes patients according to age group.

TESTS	NORMAL SUBJECTS			DIABETIC PATIENTS			$\chi^2$	P
	MEAN	SD	SEM	MEAN	SD	SEM		
1.AVLT	62.7	6.16	0.56	40.6	15.4	1.44	134.2	<0.0001(S)
2.VFT	100	00	00	77	23	2.1	80.6	<0.0001(S)
3.VRT	100	00	00	96.1	7.9	0.73	25.3	<0.0001(S)
4.WDST	96.6	8.1	0.74	55.4	25.2	2.35	22.7	<0.0001(S)
5.VST	96.8	8.23	0.8	56.1	26.9	2.5	25.7	<0.0001(S)

TABLE.NO.2:  $\chi^2$  & P values of chi-square test of memory tests of normal subjects & type 2 diabetes patients according to age group.

		NORMAL SUBJECTS			DIABETES PATIENTS			$\chi^2$	P
		MEAN	SD	SEM	MEAN	SD	SEM		
Gr. I (40 – 45yrs)	1.AVLT	65.9	4.1	0.6	52	13	2	35.04	<0.0001(S)
	2.VFT	100	0.0	00	95	8.2	1.3	7.29	<0.001(S)
	3.VRT	100	0.0	00	100	00	00	--	--
	4.WDST	99.6	2.89	0.4	76	17	2.8	0.20	>0.05(NS)
	5.VST	99.6	2.89	0.4	77	19	3	2.27	>0.05(NS)
Gr. II (46-50yrs)	1.AVLT	64	4.7	10.8	46	17	32	43.6	<0.0001(S)
	2.VFT	100	00	00	87	13	2.5	13.7	<0.001(S)
	3.VRT	100	00	00	100	00	00	2.13	>0.05(NS)
	4.WDST	97.5	6.72	1.18	59	20	3.8	5.67	>0.05(NS)
	5.VST	95.6	8.4	1.48	67	24	4.4	0.86	>0.05(NS)

**TABLE.NO.3: X<sup>2</sup> & P values of chi-square test of memory tests of normal subjects & type 2 diabetes patients according to age group.**

		NORMAL SUBJECTS			DIABETES PATIENTS			X <sup>2</sup>	P
		MEAN	SD	SEM	MEAN	SD	SEM		
Gr. III (51-55yrs)	1.AVLT	60.5	4.87	1.06	32	6.9	1.3	45.8	<0.0001(S)
	2.VFT	100	00	0.0	63	21	3.8	30.8	<0.0001(S)
	3.VRT	100	00	0.0	95	8.7	1.6	5.89	<0.05(S)
	4.WDST	95.2	10.8	2.3	41	19	3.6	12.1	<0.0001(S)
	5.VST	94.3	11.2	2.4	37	17	3.1	15.2	<0.0001(S)
Gr. IV (56-60yrs)	1.AVLT	54.9	6.74	1.59	25	4.8	1.6	37.0	<0.0001(S)
	2.VFT	100	00	0.0	48	13	3.1	37.0	<0.0001(S)
	3.VRT	100	00	0.0	86	9.2	2.2	18.9	<0.0001(S)
	4.WDST	92.2	10	2.36	32	20	4.6	11.9	<0.0001(S)
	5.VST	92.2	12.2	2.86	30	12	2.9	26.6	<0.0001(S)

**TABLE.No.4: X<sup>2</sup> & P values of chi-square test of memory tests of normal subjects & diabetic patients according to gender.**

TEST	NORMAL SUBJECTS (MALES)			DIABETES PATIENTS (MALES)			X <sup>2</sup>	P
	MEAN	SD	SEM	MEAN	SD	SEM		
1.AVLT	63.3	6.1	0.69	36.5	15	1.7	117.8	<0.0001(S)
2.VFT	100	0.0	0.0	73	24	2.8	55.7	<0.0001(S)
3.VRT	100	0.0	0.0	95	8.9	1	23.8	<0.0001(S)
4.WDST	97.7	7.1	0.8	50	21	2.4	15.3	<0.0001(S)
5.VST	98.7	4.9	0.55	51	22	2.6	18.8	<0.0001(S)

**TABLE TABLE.No.5: X<sup>2</sup> & P values of chi-square test of memory tests of normal subjects & diabetic patients according to gender.**

TEST	NORMAL SUBJECTS(FEMALES)			DIABETES PATIENTS(FEMALES)			X <sup>2</sup>	P
	MEAN	SD	SEM	MEAN	SD	SEM		
1.AVLT	61.7	6.1	0.97	47.6	14	1.9	25.9	<0.0001(S)
2.VFT	100	0.0	0.0	84	19	2.7	25.1	<0.0001(S)
3.VRT	100	0.0	0.0	99	5.2	0.7	2.97	>0.05(NS)
4.WDST	96	8.1	1.28	64	30	4.2	10.4	<0.001(S)
5.VST	92	11.8	1.87	64	33	4.6	8.32	<0.01(S)

In this study Diabetes patients were divided into 4 groups according to their age as; Gr. I – 40-45yrs (n=35), Gr. II – 46-50yrs (n=31), Gr.III – 51-55yrs (n=30) & Gr. IV – 56-60yrs (n=18). The normal subjects were also grouped in the similar manner for the purpose of statistical analysis.

**1. Auditory verbal learning test:**

Table No.1& 2. All normal subjects scored >40%. In 34% Diabetes patients score was found to be >40%. And 66% of the diabetes patients scored <40% (P value< 0.0001). Refer Table No.2. The memory score of normal subjects of Gr. I Age group was found to be 65.9% where as diabetes

patients of Gr. I age group scored 52% (X<sup>2</sup> = 35.04, P<0.0001).The memory score of normal subjects of Gr-II Age group was found to be 64% where as diabetes patients of Gr-II age group scored 46%(X<sup>2</sup> =43.64, P<0.0001).Refer Table No.3.The memory score of normal subjects of Gr-III Age group was found to be 60.5% where as diabetes patients of Gr-III age group scored 32%(X<sup>2</sup> =45.89, P<0.0001). Refer Table No.3.The memory score of normal subjects of Gr-IV Age group was found to be 54.9% where as diabetes patients of Gr-IV age group scored 25% (X<sup>2</sup> =37.0, P<0.0001). Refer Table No.4. The memory score of normal male subjects was found to be 63.3% whereas score of male diabetes patients was found to

be 36.5% ( $X^2 = 117.8$ ,  $P < 0.0001$ ). Refer Table No.5. The memory score of normal female subjects was found to be 61.7% whereas score of female diabetes patients was found to be 47.6% ( $X^2 = 25.92$ ,  $P < 0.001$ ).

**2. Verbal fluency test:** Refer Table No.1 & 2. All normal subjects scored  $>80\%$  in the test. Among diabetics 49.1% patients scored  $>80\%$  and 49.9% scored  $<80\%$  ( $P$  value  $< 0.0001$ ). Refer Table No.2. The Gr. I normal subjects scored 100% in comparison with Gr. I diabetes patients who scored 95% ( $X^2 = 7.29$ ,  $P < 0.001$ ). The Gr-II normal subjects scored 100% in comparison with Gr-II diabetes patients who scored 87% ( $X^2 = 13.76$ ,  $P < 0.001$ ). Refer Table No.3. The Gr-III normal subjects scored 100% in comparison with Gr-III diabetes patients who scored 63% ( $X^2 = 30.84$ ,  $P < 0.0001$ ). The Gr-IV normal subjects scored 100% in comparison with Gr-IV diabetes patients who scored 48% ( $X^2 = 37.0$ ,  $P < 0.0001$ ). Refer Table No.4. The normal male subjects scored 100% in comparison with male diabetes patients who scored 73% ( $X^2 = 55.72$ ,  $P < 0.0001$ ). Refer Table No.5. The normal female subjects scored 100% in comparison with female diabetes patients who scored 84% ( $X^2 = 25.19$ ,  $P < 0.0001$ ).

**3. Visual reproduction test:** Refer Table No.1 & 2. All normal subjects scored 100% in the test. Whereas diabetes patients scored 96.1% ( $P$  value  $< 0.0001$ ). Refer Table No.2. The memory scores in Gr. I normal subjects & Gr. I diabetes patients found to be same (100%). As scores in both groups were same no statistical significant difference was found. The memory scores in Gr-II normal subjects & Gr-II diabetes patients found to be same (100%) ( $X^2 = 2.13$ ,  $P > 0.05$ ). Refer Table No.3. The memory scores in Gr-III normal subjects were found to be 100% when compared to the Gr-III diabetes patients 95% ( $X^2 = 5.89$ ,  $P < 0.05$ ). The memory scores in Gr-IV normal

subjects were found to be 100% when compared to the Gr-IV diabetes patients 86% ( $X^2 = 18.99$ ,  $P < 0.0001$ ). Refer Table No.4. The memory scores in male normal subjects were found to be 100% when compared to the male diabetes patients who scored 95% ( $X^2 = 23.85$ ,  $P < 0.0001$ ). Refer Table No.5. The memory scores in female normal subjects were found to be 100% when compared to the female diabetes patients who scored 99% ( $X^2 = 2.97$ ,  $P > 0.05$ ).

**4. Working digit span test:** Refer Table No.1 & 2. The memory score was found to be 96.5% in normal subjects when compared with 55.4% in diabetes patients ( $P$  value  $< 0.0001$ ). Refer Table No.2. The memory score of Gr. I normal subject was found to be 99.6% when compared to the score of Gr. I Diabetes patients (76%). This decrease was found to be statistically Non significant ( $X^2 = 0.207$ ,  $P > 0.05$ ). The memory score of Gr-II normal subject was found to be 97.5% when compared to the score of Gr-II Diabetes patients (59%) ( $X^2 = 5.67$ ,  $P > 0.05$ ). Refer Table No.3. The memory score of Gr-III normal subject was found to be 95.2% when compared to the score of Gr-III Diabetes patients (41%) ( $X^2 = 12.16$ ,  $P < 0.0001$ ). The memory score of Gr-IV normal subject was found to be 92.2% when compared to the score of Gr-IV Diabetes patients (32%) ( $X^2 = 11.99$ ,  $P < 0.0001$ ). Refer Table No.4. The memory score of normal male subject was found to be 97.7% whereas male diabetes patients scored 50% ( $X^2 = 15.35$ ,  $P < 0.0001$ ). Refer Table No.5. The memory score of normal female subject was found to be 96% whereas female diabetes patients scored 64%. The memory scores (%) in the female diabetic patients decreased and it was found to be statistically significant when compared to normal female subjects. ( $X^2 = 10.47$ ,  $P < 0.001$ )

**5. Validation span test:** Refer Table No.1 & 2. The diabetes patients scored 56.1% in

comparison with the scores of 96.1% by the normal subjects (P value <0.0001). Refer Table No.2. The Gr. I normal subjects scored 99.6% whereas in Gr. I diabetes patients score was found to be 77% ( $X^2 = 2.27$ ,  $P > 0.05$ ). The Gr-II normal subjects scored 95.6% whereas in Gr-II diabetes patients score was found to be 67% ( $X^2 = 0.86$ ,  $P > 0.05$ ). Refer Table No.3. The Gr-III normal subjects scored 94.3% whereas in Gr-III diabetes patients score was found to be 37% ( $X^2 = 15.23$ ,  $P < 0.0001$ ). The Gr-IV normal subjects scored 92.2% whereas in Gr-IV diabetes patients score was found to be 30% ( $X^2 = 26.63$ ,  $P < 0.0001$ ). Refer Table No.4. The normal male subjects scored 98.7% whereas in male diabetes patients score was found to be 51% ( $X^2 = 18.68$ ,  $P < 0.0001$ ). Refer Table No.5. The normal female subjects scored 92% whereas in female diabetes patients score was found to be 64% ( $X^2 = 8.32$ ,  $P < 0.01$ ).

All 5 tests scores were decreased & found to be statistically significant (P value <0.0001) in diabetic patients. Among these tests scoring of diabetic patients were not uniform though decreases in all tests scores were statistically significant. Memory scores of all 5 tests decreased in male diabetic patients when compared to normal male subjects & this decrease was statistically significant ( $P < 0.0001$ ). When female diabetes patients were compared with normal female subjects out of 5 memory tests memory scores in 4 tests were decreased (except VRT) & this decrease was found to be statistically significant ( $P < 0.05$ ).

In a study entitled "HPA Axis dysregulation & Memory impairments in Type 2 Diabetes mellitus" by Hannah Bruehl, Melanie Rueger, Isabel Dziobek, Victoria Sweat, Aziz Tirsi & Elizabeth Javier et.al in 2007 have reported HPA (Hypothalamo-Pituitary-Adrenal) hyperactivity and decrease of declarative memory in diabetic patients.<sup>[4]</sup>

In a study done by R.K.Solanki, Vaibhav Dubey & Deepthi Munshi "Neurocognitive impairment & comorbid depression in patients of Diabetes mellitus" on diabetes patients (n=50) & normal subjects (n=30) found that 48% of elderly diabetic patients showed cognitive impairment.<sup>[5]</sup>

Worali G, Moulton N & Briffet E studied "Effect of Type 2 Diabetes mellitus on cognitive function" in Type 2 diabetic patients >50yrs (n=90) and age matched normal subjects (n=90) and found that modified minimal score of persons with Type 2 Diabetes mellitus was 75.6 and that of normal subjects was 79.5. On the delayed word recall test, mean scores of persons with Type 2 Diabetes mellitus was 3.9 & that of normal subjects was 4.7.<sup>[6]</sup>

Ott A, Stolk R P, Van Harskamp F, Pols H A, Hofman A & Breteler M M in 1999 in prospective population based cohort study found that diabetes mellitus almost doubled the risk of dementia (relative risk, RR-1.9) & Alzheimer's Disease (RR-1.9). Patients treated with insulin were at highest of dementia (RR-4.3).<sup>[7]</sup>

In the present study, in Gr. I (40-45yrs age) & Gr. II (46-50yrs age) out of 5 tests only two tests showed statistical significant decrease (AVLT & VFT). This may be due to fewer years of duration of disease & younger age of the diabetic patients.

In this present study, when respective age groups of diabetic patients [Gr. I (40-45yrs), Gr. II (46-50yrs), Gr. III (51-55yrs) & Gr. IV (56-60yrs)] were compared with normal subjects, it was found that all the memory tests scores decreased in Gr. III & Gr. IV. This may be due to the increased age of the diabetic patient (Mean,) which is similar to work by Perlmutter LC. In this study, diabetes patients of all the age groups showed decreased memory scores when compared to their respective normal

subjects. This was observed may be due to natural aging process which accelerated the dementia of diabetes, deposition of senile plaques as age advanced, loss of  $\beta$ -cells & amyloid deposition. When the same statistical analysis was applied in age matched normal subjects, it was observed that all the memory tests except AVLT showed statistical non-significant decrease. This may be due to longer word processing time in the Gr. IV normal subjects, a same result was observed by Water G & Caplan D.<sup>[8]</sup>

AlkaM.Kanaya, Elizabeth Barrettconnor, Ginny Glidengorin & Kristine Yaffe in 2004 studied 999 white men & women aged 42 to 89 yrs. They found that women with diabetes mellitus had a 4 fold increased risk of a major cognitive decline on the VFT after 4yrs compared with non diabetic women. Their study concluded that elderly white women with diabetes had a more rapid decline in performance on the VFT compared with women with impaired glucose tolerance or normal glucose tolerance.<sup>[9]</sup>

Coker LH, Shumaker SA in their study entitled "Type 2 Diabetes mellitus & cognition; an understudied issue in women's health" reviewed 32 studies in which cognitive functioning was measured with neuropsychological tests in participants with Type 2 Diabetes and a control/comparison group without diabetes. They found that of 32 studies that reported the effects of Type 2 Diabetes on cognition in non-demented middle aged & older adults, 30 included women in their sample, & two focused exclusively on women. 20 (67%) reported that participants with Type 2 Diabetes performed more poorly than those without diabetes.<sup>[10]</sup>

In this study it was observed that female diabetic patients suffered decrease in memory status compared to normal female subjects which is same in the study done by

few workers, Edward Gregg & Coker LH.<sup>[10]</sup> In this study it was found that memory scores of all 5 tests decreased in male diabetic patients. This decrease was statistically significant. These results are agreeable to the works of R.K Solanki,<sup>[5]</sup> Woral G<sup>[6]</sup> & Ott A.<sup>[7]</sup>

This observed decrease in memory status of diabetic male and female patients was may be due to hyperglycemia,<sup>[11,12]</sup> vascular disease,<sup>[13]</sup> hypoglycemia,<sup>[14]</sup> insulin resistance & amyloid deposition<sup>[15-17]</sup> Also some of the factors combine and produce additive effect to produce cognitive decline like type of diabetes, comorbidities,<sup>[18]</sup> age of onset,<sup>[19]</sup> duration of the diabetes<sup>[20,21]</sup> & type of therapy.<sup>[22]</sup>

## CONCLUSION

The short term and working memory scores were decreased in all 5 memory tests in diabetic patients and this decrease in memory status was statistically significant when compared to normal subjects. The short term and working memory scores by the memory tests were decreased in all the 5 tests as duration of the disease increased. The decline in short term and working memory was associated with increase of age of the diabetic patients. Both male and female diabetic patients suffered decrease in memory scores but the decrease was more in males compared to females. The decreased memory status in diabetic patients may be due to many factors like hyperglycemia, hypoglycemia, Vascular disease, insulin resistance, amyloid deposition and also some of the factors combine to produce additive effects like, type of diabetes, comorbidities, age of onset, duration of the disease and type of therapy.

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## REFERENCES

1. Andrew J.Sommerfield, Vincent McAulay, Ian J. Deary, Brian M. Frier. Short-Term, Delayed, and Working Memory Are Impaired During Hypoglycemia in Individuals With Type 1 Diabetes. *Diabetes care* 2003;26:390-396
2. Martha Clare Morris, Dennis A. Evans, Liesi E. Hebert, Julia L. Bienias. Methodological issues in the study of cognitive decline. *Am J Epidemiol* 1999; 149:789-93.
3. CelileProast Lima, HaelenaAmieva, Jean Francois Dartigues, Helene JaquirimGadda. Sensitivity of 4 psychometric tests to measure cognitive changes in brain aging-population based studies. *Am J Epidemiol* 2007; 165:344-350.
4. Hannah Bruehl, Melanie Rueger, Isabel Dziobek, Victoia Sweat, Aziz Tirsi, Elizabeth Javier, et.al. HPA Axis dysregulation & Memory impairments in Type 2 Diabetes mellitus. *J Clin Endocrinol Metab* 2007; 92:2439-2445.
5. R.K.Solanki, Vaibhav Dubey, Deepthi Munshi. Neurocognitive impairment & comorbid depression in patients of Diabetes mellitus. *Int J Diabetes Dev Ctries.* 2009;29:133-138.
6. Woral G, Moulton N, Briffet E. Effect of Type 2 Diabetes mellitus on cognitive function. *J FamPract.* 1993; 36(6):639-43.
7. Ott A, Stolk R P, Van Harskamp F, Pols H A, Hofman A, Breteler M M. Diabetes mellitus and the risk of dementia: The Rotterdam Study. *Neurology.* 1999;53:1937-42.
8. Waters G, Caplan D. The relationship between age, processing speed, working memory capacity & language comprehension. *Memory* 2005;13:403-13.
9. AlkaM.Kanaya, Elizabeth barrettconnor, Ginny Glidengorin, Kristine Yaffe. Change in cognitive function by glucose tolerance status in older adults. *Arch Intern Med* 2004; 28:64.
10. Coker LH, Shumaker SA. Type 2 Diabetes mellitus & cognition; an understudied issue in women's health. *J Psychosom Res.* 2003; 54:129-39.
11. Toth C, Schmidt AM, Tuor UI, Francis G, Foniok T, Brussee V, et al. Diabetes, leukoencephalopathy and rage. *Neurobiol Dis* 2006; 23:445-461.
12. Sredy J, Sawicki DR, Notvest RR. Polyol pathway activity in nervous tissues of diabetic and galactose-fed rats: effect of dietary galactose withdrawal or tolrestat intervention therapy. *J Diabet Complications* 1991; 5:42-47.
13. McCall AL. The impact of diabetes on the CNS. *Diabetes* 1992; 41:557-570.
14. Comi G. Evoked potentials in diabetes mellitus. *Clin Neurosci* 1997; 4:374-379.
15. Ibberson M, Uldry M, Thorens B. GLUTX1, a novel mammalian glucose transporter expressed in the central nervous system and insulin-sensitive tissues. *J BiolChem* 2000; 275:4607-4612.
16. Lupien S, Lecours AR, Lussier I, Schwartz G, Nair NP, Meaney MJ. Basal cortisol levels and cognitive deficits in human aging. *J Neurosci* 1994; 14:2893-2903.
17. Gasparini L, Gouras GK, Wang R, Gross RS, Beal MF, Greengard P, et al. Stimulation of  $\beta$ -amyloid precursor protein trafficking by insulin reduces intraneuronal  $\beta$ -amyloid and requires mitogen-activated protein kinase signaling. *J Neurosci* 2001; 21:2561-2570.

18. Rosebud O. Roberts, Yonas E. Geda, David S. Knopman, Teresa J.H. Christianson, V. Shane Pankratz, Bradly F. Boeve, et.al. Association of Duration and Severity of Diabetes Mellitus with Mild Cognitive Impairment. ARCH NEUROL 2008; 65:1066-1073.
19. Weli Xu, Chengxuan Qiu, Margaret gatz, Nancy L. Pedersen, Boo. Johansson, Laura Fratiglioni. Mid- and Late-Life Diabetes in Relation to the Risk of Dementia. Diabetes 2009; 58:71-77.
20. Renata C Alencar, Roberta A Cobas, Marilia B Gomes. Assessment of cognitive status in patients with type 2 diabetes through the mini-mental status examination: a cross-sectional study. Diabetology & Metabolic Syndrome 2010;2:10.
21. Ebady SA, Arami MA, Shafiq MH. Investigation on the relationship between diabetes mellitus type 2 and cognitive impairment. Diabetes Res ClinPract. 2008;82:305-9.
22. Jane S. Saczynski , Maria K. Jonsdottir, Melissa E. Garcia, Palmi V. Jonsson, Rita Peila, Gudny Eiriksdottir, et.al. Cognitive Impairment: An Increasingly Important Complication of Type 2 Diabetes, The Age, Gene/Environment Susceptibility–Reykjavik Study. Am J Epidemiol 2008;168:1132–1139.

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