LIVING WITH DIABETES MELLITUS II: IMPACTS ON NEUROPSYCHOLOGICAL FUNCTIONING DEPRESSION AND QUALITY OF LIFE

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Article Info: Received 21 March 2019; Accepted 06 April. 2019

Cite this article as: Raj, T. (2019). LIVING WITH DIABETES MELLITUS II: IMPACTS ON NEUROPSYCHOLOGICAL FUNCTIONING DEPRESSION AND QUALITY OF LIFE. *International Journal of Medical and Biomedical Studies*, 3(4).

DOI: <https://doi.org/10.32553/ijmbs.v3i4.154>

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Conflict of interest: No conflict of interest.

Abstract

The aim of the present study was to examine the relationship between neuropsychological functioning, depression and quality of life among adults with diabetes mellitus-II. The study used a quantitative approach with an experimental, cross sectional matched group research design. The sample was divided into two groups; an experimental group of adults with diabetes mellitus and a control group of matched healthy individuals, with 30 participants in each group. The sample was recruited from Delhi using convenience and snowball sampling. A self designed questionnaire was administered for understanding about diabetes and its management in the experimental group. NIMHANS neuropsychological battery and WAIS- IV (Two subtests only), Beck Depression Inventory and WHOQOL questionnaire was used for examining neuropsychological functioning, depression and quality of life among adults with diabetes mellitus and matched healthy individuals. Participants among adults with diabetes mellitus group were provided a self –designed brochure on the self-management of diabetes. Descriptive statistics like frequency, percentage etc and inferential statistics like MNOVA and correlations were used for analysis of the data. Results indicated a significant relationship on total neuropsychological functioning between the two groups. Significant differences were found in some components of neuropsychological functioning, viz. executive functions, attention and working memory. Non-significant relationships were found on depression and quality of life. The experimental group was aware about diabetes and its management. Awareness and motivation for self-management provides better health outcomes. Comprehensive psychosocial and behavioural interventions by psychologists can delay complications of neuropsychological functioning of individuals with diabetes mellitus.

Key words: Diabetes mellitus II, Neuropsychological Functioning, Depression, Quality of life.

INTRODUCTION:

Diabetes is spoken about a lifestyle disease, often associated with higher risk of some macro and micro vascular complications. These

complications cause mortality rate among diabetic patients to be about twice that of non-diabetic individuals of similar age (Seshasai et al., 2011; Guzder et al., 2007). Moreover, patients with these complications have lower quality of

life than diabetes patients without complications (Oliva et al., 2012; Wu et al., 2012).

India leads the world with largest number of diabetic subjects earning the dubious distinction of being termed the “diabetes capital of the world”. According to the diabetes atlas (2006) published by the IDF, the number of people with diabetes in India currently around 40.9 million is expected to rise to 69.9 million by 2025 unless urgent preventive steps are taken (Mohan et al., 2007).

Diabetes has become one of the debilitating chronic diseases with effects on several aspects of daily living. Diabetes as a disease not only effects, one’s diet or the physical symptoms but also the occupational like stop working prematurely (Herquelot et al., 2011) , may have to face unemployment (Latif, 2009; Robinson et al., 1989), which will further lead into reduction in their income (Mayfield et al., 1999) and in return will impact their self – esteem (Smith et al., 1985) Psychological health is another aspects which gets impaired along with above impairments. Sleep disturbances are prevalent among adults with diabetes mellitus and is positive correlated such as restless leg syndrome, sleep apnea and nocturia (Plantinga, Rao & Schillinger, 2012). Similarly people with diabetes are at increased risk of cardiovascular, peripheral vascular and cerebrovascular disease (WHO, 1999).

Diabetes Mellitus and Quality of Life

Researchers have shown that there is direct impact of quality of life of people with diabetes and it varies with several other factors. In the absence of information for correct lifestyle, people with diabetes have shown poor health related quality of life (Kiadaliri et al., 2013; Kumar and Krishna, 2015; Oprah, 2008). In the presence of training and workshops on lifestyle management for diabetes, people with diabetes have shown moderate quality of life (Mathew et al., 2014;). Cognitive dysfunction and depression are both predictors of health related quality of life. Individuals with diabetes have negative

health beliefs with respect to health related quality of life (Sarfo et al., 2015).

Diabetes Mellitus and Neuropsychological Functioning

Cognitive dysfunction is one of the complications of diabetes mellitus. Some of them include slowing of mental speed and diminished mental flexibility (Augustina et al., 2005) and decrement in attention, working memory, verbal memory, processing speed and executive function (Takeuchi et al., 2012). Similarly Tiwari et al., (2012) found that adults with diabetes mellitus were at 1.3 times risk to develop cognitive impairment. There is direct mechanism between cognitive impairment and diabetes mellitus 2 as explained by Vijaykumar et al. (2012) in the following figure 2. Cognitive impairment happens because of the several mechanisms that begins along with increase or decrease in sugar level of the blood and level of insulin production.

Figure 1: Possible Mechanisms related to cognitive decline in diabetes mellitus patients (Vijaykumar et al., 2012).

Diabetes Mellitus and Depression

Depression and diabetes are both chronic illnesses. There is a bidirectional relation between diabetes and depression (Katon, 2008). The prevalence of depression is inevitable as a co-morbid condition with diabetes mellitus

(Ravishankar et al., 2014). Diabetes is affectively stressful, influences pathophysiological mechanism of the body as well as mood. The nature of depression in individuals with diabetes is highly persistent and recurrent, further impacting clinical outcomes and quality of life. The coexistence of both diabetes and depression is associated with morbidity, mortality and increased healthcare cost (Andreoulakis et al., 2012) (figure 2).

Figure 2: Co- morbid relationship between Depression and Diabetes (Banwari, 2013).

Diabetes Mellitus, Depression, Quality of life and Neuropsychological Functioning

Researchers have found that adults with diabetes mellitus can have significant effects on neuropsychological functioning, depression and quality of life each, and also possibly affecting and influencing each other (Sarfo and Kole, 2014; Solanki, Dubey and Munshi, 2009). Derakhshanpour, Vakili, Farsinia and Mirkarimi (2015) found 58.2% prevalence of depression among patients with diabetes and 24.7% patients had poor quality of life. The study concluded with high depression in patient with diabetes and a considerable impact on the consequences of diabetes and quality of life. Similalry another study found 48% and 36% of diabetic patients were showing cognitive impairment and

depression respectively (Solanki, Dubey and Munshi, 2009). Another study by Watari et al., (2006) found significant differences in overall cognitive functioning among adult with diabetes mellitus and depression compared to adults with diabetes mellitus without depression.

A common suggestion among most of the studies is that early detection and treatment may mitigate its cognitive sequel and proper management of depression may increase the compliance with treatment and prolong independence and quality of life in diabetes patients. They also recommend that besides regular doctor's visits in terms of physical problems, regular psychiatrist's visits or psychological assessments for screening mental disorders can help early diagnosis of these disorders.

Diabetes mellitus is a chronic disease, with several disabilities associated with it, in almost all domains of life. To reduce disability, examining of the factors contributing to the disability and poor quality of life becomes essential. Therefore, this study aims at examining two of the contributing factors i.e. neuropsychological functioning and depression. Results of the present study can provide insights into possible psychological interventions that can be used to help adults with diabetes mellitus to improve their quality of life. No studies examine the relationship between diabetes mellitus, neuropsychological functioning, depression and quality of life. This study is a step to establish the comprehensive relationship between the variables under study.

Objectives

The objectives of the present study are as follow:

- To compare neuropsychological functioning of adults with diabetes mellitus and adults without diabetes mellitus.
- To associate depression of adults with diabetes mellitus and adults without diabetes mellitus.

➤ To compare quality of life of adults with diabetes mellitus and adults without diabetes mellitus.

➤ To study the relationship between neuropsychological functioning, depression and quality of life of adults with diabetes mellitus.

Hypothesis

On the basis of above objectives, following hypothesis were derived:

HO 1 - There will be no significant difference between diabetic group and control group on neuropsychological functioning.

HA 1 - There will be significant difference between diabetic group and control group on neuropsychological functioning.

HO 2 - There will be no significant difference between diabetic group and control group on depression.

HA 2 - There will be significant difference between diabetic group and control group on depression.

HO 3 - There will be no significant difference between diabetic group and control group on quality of life

HA 3 - There will be significant difference between diabetic group and control group on quality of life.

Methods

The aim of the present study was to study the relationship between neuropsychological functioning, depression and quality of life among adults with diabetes mellitus type II. The present study has used a quantitative research design, along with experimental, cross sectional matched group design. The independent variable and dependent variable are diabetes mellitus type II and neuropsychological functioning, depression and quality of life respectively.

Sample

Sample consisted of total 60 participants. It comprised of two groups, the experimental group which included adults with diabetes mellitus, and the control group which had matched healthy control individuals who did not have diabetes mellitus. Both the groups included

30 participants each, and were matched on age, gender, educational qualification, occupation, socio-economic status, rural and urban residence and religion. Convenience and Snowball sampling was used. The age range selected for participants was 40-60 years. Inclusion criteria, diagnosis of diabetes mellitus type II, with minimum two years of diagnosis and medical adherence and Exclusion criteria, like absence of history of any neurological problems head injury were for participants in adults with diabetes mellitus. On the other hand, for Participants in matched healthy control group didn't had diagnosis of diabetes mellitus and any history of neurological problems.

Measures

A socio-demographic and clinical data sheet was prepared by the researcher. It had two sections, first, named as socio-demographic profile which included age, gender, educational qualification, occupation, socio-economic status, urban/rural and religion. Second, referred as the clinical profile which included hemoglobin level, fasting glucose sugar level, duration of diabetes, co-morbid medical condition, history of psychological condition and history of substance use, though for control group questions related to diabetes were not asked. For a better understanding of diabetes mellitus and its influences on its management, a questionnaire was self designed and administered face to face, which also included the influence or changes in the lifestyle as a result of diabetes. The NIMHANS Neuropsychological Battery (Rao, Subbakrishna & Gopukaumar, 2004) was used for the clinical examination of both the working brain and dysfunctional brain with an adjective to chart the deficits and adequacies in the psychological function and brain structural/functional networks. From the battery, 8 tests were used to measure executive functions and working memory neuropsychological domains, as indicated in Table 1, with the respective measures of functions.

Table 1: Name of tests with respective author and functions used from NIMHANS Neuropsychological Battery.

Author of the Tool	Name of the test	Function
Meyers and Meyers, 1995	Complex Figure Test	Visual Spatial Construction and visual learning and memory
Benton and Hamsher, 1989	Controlled Oral Word Association Test	Verbal Fluency
Lezak, 1995	Animals Names Test	Category Fluency
D'Elia, Satz, Uchiyama & White, 1996	Color Trail (1 and 2)	Focused attention and cognitive flexibility
Alexander, Benson & Struss, 1989	Stroop Test	Response Inhibition
Schmidt, 1996	Auditory Verbal Learning Test	Verbal learning and memory
Wechsler, 1981	Digit Symbol Substitution Test	Mental Speed
Lezak, 1995	Digit Vigilance Test	Sustained Attention

The two subtests of Wechsler Adult intelligence Scale IV (WAIS –IV)(Wechsler, Coalson and Raiford, 2008), Digit Span Test and Letter Number Sequencing Test was used with the aim of assessing attention and working memory neuropsychological functions. For the assessment of prevalence of depression and its characteristics attitudes and symptoms, the Beck depression Inventory I (BDI- I) (Beck, Ward, Mendelson, Mock & Erbaugh, 1961) was used. Along with the English version, Hindi version done by Chatterjee (2016) was used. World Health Organization quality of life questionnaire (WHOQOL, Bref, 1997) was to assess individual's perceptions in the context of their culture and value system, and their personal goals, standards and concerns divided into following domains, physical health, psychological health, social relationships and environment. This questionnaire was translated to Hindi and back translated to English.

A brochure was self designed on the self management of diabetes mellitus type 2 emphasizing self care and motivation enhancement which was given to the participants of diabetes mellitus group at the end of the assessment.

Procedure

The study was conducted in two phases, pilot and main phase. Post the pilot phase slight changes were made for better administration. For the participants from the group of adults with diabetes mellitus, a brief assessment of

understanding and self management of diabetes was carried initially. The rest of the administration included assessment of neuropsychological tests, followed by BDI and WHOQOL administration. The time as per required by specific assessments were noted. The complete process took approximately two hours. After complete assessment a brochure on information for self management of diabetes was given to the participant.

Statistical Analysis

A summary sheet was created to hall all the scores for a participant in an organized way. All the tests raw scores and respective percentile was entered in the summary sheet of each participant. All the data was coded and verified and entered on SPSS/Excel. Descriptive and Inferential statistics was used for analyzing the data, given the quantitative nature of the data obtained. SPSS 20 was used for the computation of the data. Mean, range, cross tabulation, frequency and percentage were computed for the socio-demographic data obtained along with the data obtained from self prepared questionnaire on understanding and self management of diabetes. MANOVA was conducted to calculate the significant differences between both the groups. MANOVA was especially used with the consideration of three dependent variables (neuropsychological functioning, depression and quality of life) and one independent variable (diabetes mellitus type 2). Correlation was computed among all the

dependent variables only in the group of adults with diabetes mellitus, along with some other factor correlations with similar variables.

Results

The results of the present study have been analyzed using data obtained from self – made questionnaires and the standardized assessment

tools. Results have been divided under the following sub heads.

Socio- demographic Description of the Sample

Mean, Frequency and Percentage were used to compute socio-demographic profile of the sample. As it can be seen from table 3, the mean age of the sample was 51.70 years, ± 5.08 .

Table 2: Range, mean age (in years) and standard deviation of the participants (N=60).

Variable	Range		Mean	Standard Deviation
Age (years)	Minimum	Maximum	51.	5.08
	42	60	70	

Table 3: Frequency and percentage distribution of gender, education and occupation of the participants (N=60)

Variable		Frequency	Percentage
Gender	Male	48	80
	Female	12	20
Education	12 th	2	3.3
	Undergraduate	34	56.7
	Postgraduate	24	40
Occupation	Government service	54	90
	Housewife	6	10

From Table 3 it can be seen that, there was inequitable distribution of male (80%) and female (20%) in the present study. Though, all the participants were educated and ninety percent of the sample worked in a national level government organization.

Clinical Profile of Participants with Diabetes Mellitus

Table 4: Range and Mean of HbA1c level and FPG level; Frequency and Percentage distribution of duration, co-morbid medical condition and history of substance use of participants of group of adults with diabetes mellitus (N=30)

Variable	Range		Mean	Standard Deviation
	Minimum	Maximum		
Hba Level (>6.5%, impaired glucose tolerance)	6.05	18.00	10.94	3.07
FPG/VPG level (70,000-90,000mg/dl)	205000	315000	153100.00	48535.34
		Frequency	Percentage	
Duration	2-5years	8	26.67	
	6-10 years	10	33.33	
	11years or more	12	40	
Co-morbid medical condition	Total with co-morbid condition	19	63.33	
	Blood Pressure	12	40	
	Cholesterol	2	6.67	
	Thyroid	2	6.67	
	Others	3	10	
	Adults without co-morbid	11	36.66	

	condition		
History of Substance use	Present	8	26.67
	Absent	22	73.33

As it can be seen from the table 4, 12 participants (40%) of the sample had diabetes for 11 or more years and a comparable 10 participants (33.33%) had diabetes for 6-10 years. Table 5 also depicts the mean HbA1c level of the present sample that is 10.94 ± 3.07 . The highest HbA1c level in the sample was 18% whereas the minimum HbA1c level in the sample was 6.05 which indicate quite low blood sugar. The mean FPG level of the present sample is $1,53,100 \text{ mg/dl} \pm 48535.34$, which indicates of being high as per the normal range (70,000mg/dl - 90,000mg/dl). The maximum level of FPG in the

present sample was 3,15,000 mg/dl and the minimum level of FPG was 2,05, 000mg/dl. Therefore the range of the FPG value in the present study is quite higher than the normal range. Also in the present study, the participants with high HbA1c also had had high FPG levels. There was 63.33% of the sample who had co-morbidities with diabetes (Table 4). There was 40% of the sample who had blood pressure problems; other co-morbidities included cholesterol (6.67%), thyroid (6.67%) and other (10%) in comparable numbers.

Table 5: Range, mean and standard deviation of Age of Onset of diabetes for participants of group of adults with diabetes mellitus (N=30)

Variable	Range		Mean	Standard Deviation
Age of onset of diabetes (years)	Minimum	Maximum	42.00	6.47
	28	54		

Table 6: Division of Group of Adults with diabetes mellitus and respective gender difference on the basis of age of onset. (N=30)

Group Name	Number of participants (Percentage)	Gender Difference	
		Male	Female
Early onset among adults with diabetes mellitus (Less than 45 years)	18 (60%)	14	4
Usual Onset among adults with diabetes mellitus (45 years or more)	12 (40%)	10	2

Table 5 depicts minimum age of onset as 28 years. Among the group of adults of diabetes mellitus, 60% of the adults had early onset of disease (table 6).

Table 7: Cross Tabulation for Early Age of Onset (less than 45 years) with duration of illness, presence of co-morbid medical condition and history of substance use for participants of group of adults with diabetes mellitus

Early Age of onset (Less than 45 years old)																		
Number of Participants	2	3	4	5	7	8	9	10	13	16	19	20	22	23	25	26	27	28
Gender	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	M	M
Duration (in years)	6	4	14	3	12	13	10	10	8	17	16	24	15	20	18	6	7	13
Co-morbid Medical conditions	x	x	v	v	v	x	v	v	v	x	v	v	v	v	v	v	v	v
History of substance use	v	v	x	v	x	x	x	v	v	x	x	x	x	x	x	x	x	x

v-Presence ; x- Absence

M- Male ; F- Female

Table 8: Cross Tabulation for Usual Age of Onset (45 years or more) with duration of illness, presence of co-morbid medical condition and history of substance use among participants of group of adults with diabetes mellitus.

√-Presence ; ×- Absence

M-	Age of onset: 45 years or more											
Number of Participants	1	6	11	12	14	15	17	18	21	24	29	30
Gender	M	M	M	M	M	M	M	M	F	F	M	M
Duration (in years)	6	8	6	3.5	14	5	3	4	5	11	2	10
Co-morbid Medical conditions	×	×	×	√	×	×	×	√	√	√	×	×
History of substance use	×	×	×	×	√	√	×	√	×	×	×	×

Male ; F- Female

On comparing the group of adults with early onset (Table 8) with the group of adults with usual onset of diabetes (Table 9), it can be seen there is greater presence of co-morbid complications in the group with early onset of diabetes mellitus.

Understanding of Diabetes Mellitus among the Adults with Diabetes Mellitus

Figure 3: Percentage distribution of presence of family history of diabetes among participants of group of adults with diabetes mellitus (N=30)

Figure 4: Percentage distribution of acceptance of diabetes as a disease among participants of group of adults with diabetes mellitus (N=30)

Majority (77%) of the sample had a family history of diabetes (figure 6) and 86.66% of the sample had completely accepted the disease diagnosis whereas 3.33% of sample had very little acceptance (figure 7).

Figure 5: Frequency distribution of understanding of diabetes as a disease among participants of group of adults with diabetes mellitus (N=30)

As it can be seen from the figure 8, in the group of participants with diabetes mellitus there was an understanding of diabetes and perception of diabetes as a disease. The sample collectively held four views of the disease such as “it is a disease that I will have to live with for the rest of my life”, “it is a lifestyle disease”, “it is stress related” and “it is genetic”.

Figure 6: Percentage distribution of first thoughts with diagnosis of diabetes among participants of group of adults with diabetes mellitus (N=30)

As it can be seen from the figure 9, 31% of the sample felt that diabetes had happened due to their lifestyle; and another comparable 28 percent of the sample said that they were prepared for it due to presence of genetic understanding.

Self-management of diabetes

Figure 7: Percentage distribution of check of blood sugar among participants of group of adults with diabetes mellitus (N=30)

Figure 10 shows that 57% of the sample occasionally checked their blood sugar and 40% of the sample did so once a week, or more often.

Figure 8: Percentage distribution of frequency of visit to diabetologist among participants of group of adults with diabetes mellitus (N=30)

As it can be seen from figure 11, 33% of the sample visited their diabetologist once a month and a comparable (37%) participants had a visit to their diabetologist once in three months. Also 27% of the sample visited the diabetologist, though only when they felt like it. Only 3% of the sample mentioned not having a diabetologist.

Figure 9: Percentage distribution of meal plan among participants of group of adults with diabetes mellitus (N=30)

As it can be seen from figure 12, 70% of the sample had a meal plan and 40% of such participants mostly followed the meal plan along with regular practice of exercise (70%).

Figure 10: Percentage distribution of medicine care among participants of group of adults with diabetes mellitus (N=30)

64% of the sample take medicines on a very regular basis, and 3% of sample used to be irregular but has become regular now (figure 10).

Figure 11: Percentage distribution of alternative home remedies among participants of group of adults with diabetes mellitus (N=30)

47% of the present sample had been using alternative home remedies to support their management of diabetes. Home remedies used by the present sample were bitter gourd, neem, aloe vera, methi etc. (figure 11).

Figure 12: Percentage distribution of changes in lifestyle pattern and diet among participants of group of adults with diabetes mellitus (N=30)

Some of the lifestyle changes made by the participants of the present study included increase intake of vegetables and other foods high in dietary fibre, reduction in amount of saturated fats in food, avoiding fasting and heavy meals and most importantly presence of exercise and meditation.

Quantitative Analysis

Under this section results are calculated objective wise. For the following three objectives, MNOVA was conducted followed by correlation for the fourth objective. An overall MNOVA was conducted between both the groups.

Table 9: Two – way MNOVA and Partial Eta Squared of adults with diabetes mellitus and matched healthy individuals. (N= 60).

Variable	F	Sig.	Partial Eta Squared
Group	4.975*	0.000	.668

*Significant at $p < 0.001$

There is a statistically significant interaction effect between neuropsychological functioning, depression and quality of life on the diabetes mellitus at the $p < 0.001$ [$F = 4.277$, $p = 0.000$] (table 9).

Neuropsychological Functioning and Diabetes mellitus

Table 10: Summary Table of Mean, Standard Deviation, F value of Two – way MNOVA and Partial Eta squared of neuropsychological functioning among adults with diabetes mellitus and matched healthy individuals (N= 60).

Variable	Diabetes Mellitus (N=30)	Matched Healthy Individuals (N=30)	F	Sig.	Partial Eta Squared
	Mean (SD)	Mean (SD)			
Total Neuropsychological Functioning	53.97 (9.48)	60.86 (10.67)	6.973*	.011	.107
Attention	13.70 (1.96)	17.40 (2.55)	39.503*	.000	.405
Sustained Attention	531.60 (115.40)	458.13 (84.05)	7.944*	.007	.120
Working Memory	3.06 (.63)	4.23 (.97)	30.183*	.000	.342
Cognitive Flexibility	233.03 (74.60)	174.73 (39.84)	14.253*	.000	.197
Mental Speed	265.66 (70.15)	235.40 (46.08)	3.901*	.053	.063
Category Fluency	10.86 (2.96)	12.70 (2.53)	6.619*	.013	.102
Phoenic Fluency	9.32 (2.99)	11.34 (2.99)	6.824*	.011	.105
Response Inhibition	177.30 (65.80)	124.63 (37.79)	14.450*	.000	.199
Verbal Learning's Memory	74.36 (28.29)	85.06 (17.58)	3.094	.084	.051
Visual Construction and visual learning and memory	32.95 (7.84)	36.36 (6.53)	3.357	.072	.055

*Significant at $p < 0.05$

Table 13 represents the first objective of the present study, indicating a significant difference in total neuropsychological functioning between the group of adults with diabetes mellitus and matched healthy individuals at $p < 0.05$ level [$F = 6.973$, $p = 0.11$]. Therefore the results are in line with the first hypothesis; there will be significant difference between diabetic group and control group on neuropsychological functioning. This indicates that diabetes mellitus significantly affects the neuropsychological functioning of the adults.

In the components of neuropsychological functioning (table 13), between the group of adults with diabetes mellitus and matched healthy individuals, there is significant difference in attention, sustained attention, working memory, cognitive flexibility, mental speed, category fluency, phoenic fluency and response inhibition and no significant difference in verbal learning and memory and visual construction and visual learning and memory ($p < 0.05$ level).

Blood Glucose Level (FPG) and Neuropsychological Functioning.

Table 11: Pearson Moment Correlation between Neuropsychological Functioning and Blood Glucose (FPG) level (N= 30).

Variable	Total Neuropsychological Functioning	Significant value
Blood Glucose (FPG) Level	.027	.889

A Pearson moment correlation coefficient was computed to assess the relationship between total neuropsychological functioning and blood glucose (FPG) level (table 11). There was a positive correlation between neuropsychological function and blood glucose (FPG) level [$r = .027$, $n = 30$ $p = 0.889$]. This indicates increase in blood glucose level is correlated with increase in impairment in neuropsychological functioning.

Glycated Hemoglobin (HbA1c) and Neuropsychological Functioning.

Table 12: Correlation between Neuropsychological Functioning and HbA1c level (N= 30).

Variable	Total Neuropsychological Functioning	Significant value
HbA1c Level	.313	.093

A Pearson moment correlation coefficient was also computed to assess the relationship between total neuropsychological functioning and hemoglobin (HbA1c) level (table 12). There was a positive correlation between neuropsychological function and hemoglobin level (HbA1c) [$r = .313$, $n = 30$ $p = 0.093$]. Therefore there is a presence of overall a positive correlation between neuropsychological function and hemoglobin level.

Depression and Diabetes Mellitus

Table 13: Frequency and Percentage of Depression and levels of depression among adults with diabetes mellitus and matched healthy individuals (N= 60).

Variable	Diabetes Mellitus (N= 30)		Matched Healthy Individuals (N=30)	
	Frequency	Percentage	Frequency	Percentage
Total Depression	28	93.33	29	96.66
Low Depression	25	83.33	26	86.66
Moderate Depression	3	10	4	13.33
Severe Depression	2	6.66	0	0

Table 13 represents the frequency and percentage of depression among adults with diabetes and matched healthy individuals. 93.33% of the adults with diabetes mellitus had depression and 97% of the matched healthy individuals also had depression. This indicates that there are no significant differences in prevalence of depression, between both the groups of adults with diabetes and matched healthy individuals, which is also shown by the MANOVA conducted between both the groups on total depression (table 14). Though among the group of adults with diabetes mellitus, 6.66% had severe level of depression and 10% had moderate level of depression where as the matched healthy individuals had zero percent severe depression

Table 14: Summary Table of Mean, Standard Deviation, F value of Two – way MNOVA and Partial Eta squared of Depression among adults with diabetes mellitus and matched healthy individuals (N= 60).

Variable	Diabetes Mellitus (N= 30)	Matched Healthy Individuals (N=30)	F	Sig.	Partial Eta Squared
	Mean (SD)	Mean (SD)			
Total Depression	10.63 (9.79)	8.5 (6.25)	68.267	1.011	.319

Table 14 depicts the second objective of the present study, indicating no significant difference in total depression between the group of adults with diabetes mellitus and matched healthy individuals at $p < 0.05$ level [$F = 68.267$, $p = 1.011$]. Therefore the results are in line with the second hypothesis; there will be no significant difference between diabetic group and control group on depression. This indicates that diabetes mellitus did not significantly affect the depression of the adults in the present study.

Quality of life and Diabetes Mellitus

Table 15: Summary Table of Mean, Standard Deviation, F value of MNOVA and Partial Eta squared of Depression among adults with diabetes mellitus and matched healthy individuals (N= 60).

Variable	Diabetes Mellitus (N=30)	Matched Healthy Individuals (N=30)	F	Sig.	Partial Eta Squared
	Mean (SD)	Mean (SD)			
Total Quality of Life	101.00 (12.58)	103.00 (8.05)	.932	.338	.016
Physical Quality of life	27.33 (4.09)	29.30 (2.43)	5.633*	.021	.089
Psychological Quality of Life	23.00 (3.55)	23.43 (2.90)	.267	.607	.005
Social Quality of Life	12.36 (1.97)	12.50 (1.67)	.080	.779	.001
Environmental Quality of Life	30.67 (4.67)	30.67 (3.24)	.000	1.000	.000

*Significant at $p < 0.05$

Table 15 examines the third hypothesis, indicating no significant difference in total quality of life between the group of adults with diabetes mellitus and matched healthy individuals at $p < 0.05$ level [$F = .932$, $p = .338$]. Therefore the results are in line with the third hypothesis; there will be no significant difference between diabetic group and control group on total quality of life.

Among the four components of total quality of life (table 15), there was significant difference in physical quality of life [$F = 5.633$, $p = 0.021$] and at $p < 0.05$ level between the group of adults with diabetes mellitus and matched healthy individuals.

Neuropsychological Functioning, Depression, Quality of life and Diabetes Mellitus

The last objective of the present study was to examine the relationship between neuropsychological functioning, depression and quality of life among adults with diabetes mellitus and to examine this relationship, a Pearson product moment correlation coefficient was computed.

Table 16: Summary Table of Pearson Correlation between Neuropsychological Functioning, Depression and Quality of life among adults with diabetes mellitus and matched healthy individuals (N= 60).

Variable	Depression	Quality of life	Total Neuropsychological Functioning
Depression	1	-.110	-.183
Quality of life	-.110	1	.212
Total Neuropsychological Functioning	.183	.212	1

Table 19 indicates, that there is a positive correlation between total neuropsychological functioning and quality of life [$r = .212$, $n = 30$ $p = 0.261$]. This indicates that better neuropsychological functioning is correlated with higher quality of life. There is a negative correlation indicated between depression and neuropsychological function [$r = -.183$, $n = 30$ $p = 0.334$](Table 19). This indicates increase/improvement in neuropsychological functioning is correlated with decrease in depression level.

Lastly it can be seen from table 19, that there was a negative correlation between quality of life and depression [$r = -.110$, $n = 30$ $p = 0.564$]. This indicated that an increase in depression was correlated with decrease in quality of life.

Overall the above correlations were not strong and significant but were in the expected directions. However a relationship or an equation among neuropsychological functioning, depression and quality of life among adults with diabetes mellitus could not be established because of some of the statistical non- significant results among both the experimental and control groups.

Discussion

To my knowledge this is one of the first studies examining the relationship between, neuropsychological functioning, depression and quality of life among diabetes mellitus. Overall, the present study has found significant effects on neuropsychological functioning, high prevalence

of depression and a moderately affected quality of life.

In the present study, there was no impact of the diabetes on the employment of the participants (table 3), indicating the stable financial status of their households. This itself was contrast to previous studies, where diabetes have showed an adverse impact on the employment of adults (Derakshanpur, Vakilli, Fassimia and Mirkarimi, 2015). Most of the participants of the present study were working in government organizations where provision of medical facilities for employees and their family were present. This implies that affordability of health treatment and its requirement was present without any difficulty.

Majority of the sample had diabetes for more than five years, indicating possible familiarity with diabetes and its management, similar to the previous studies, where most of sample falls under the duration of 5 or more years (Ravishankar, Dinesh and Reddy, 2014; Mathew et al., 2014).

The contribution of early onset of diabetes increases the possibility for co- morbid complications (Wilmot and Ildris, 2014). Therefore the age of onset also contributes to the impairment in individuals neuropsychological functioning by increasing the possibilities of presence of such co-morbid complications. This was reflected in the present study(table 7), where most of the individuals with early onset

had co-morbid complications like cardiovascular problems, cholesterol, thyroid problems, etc. In the present study, among adults with early onset of diabetes mellitus, very few participants had history of substance use (Table 7). Presence of history of substance use (Takeuchi et al., 2012) is also another factor contributing in impairment of neuropsychological functioning which is not very significant contribution for the participants of the group with early onset of diabetes mellitus type 2. Though there is a possibility of participants not accepting substance use, probability due to the social desirability bias. Though in the present study in contrast to previous studies, for both the groups of onset of diabetes mellitus there is no significant contribution of the history of substance use to their neuropsychological functioning.

In the present study, participants were moderately aware about diabetes and its related understanding. 86.66% of the sample had completely accepted the disease diagnosis (figure 4). This could be a probable result of the familiarity with the disease as 77% of the sample had family history of diabetes (figure 3). Also the long duration of being with diabetes and its complications supports such presence of understanding of diabetes as a disease (table 4). This all together indicates their familiarity and adaptability with treatment procedures is possibly quite high. Probably this increase in familiarity with disease and outcomes of treatment has contributed to such complete acceptance and understanding of diabetes as a disease in majority of the sample.

31% of the sample felt that diabetes had happened due to their lifestyle; and another comparable 28 percent of the sample said that they were prepared for it (figure6). This could be because of the familiarity with the diabetes as a disease and its treatment. Along with it, there was also an understanding that it was a genetic disease which helped the participants to know in advance that they were the potential individuals for diabetes mellitus. Some of them did mention about maintaining their diets before diagnosis

which could contribute to late onset of the disease. Though there were some of the participants who had tough time accepting their diabetes, probably might have been resistant present initially in some of the participants especially with early onset like “I didn’t know what to accept” (13%); “I will have to travel a rough road” (10%); “my life as I knew it was over” (9%) (figure6). Though with the duration (table 4) of more than 11 or more years (40%), outcomes of their adaptability with illness and its treatment procedures probably had helped the participants adjust with the initial resistance with their diabetes as a long term illness.

Diabetes management demands several changes in the lifestyle of an individual (Asif, 2014). Maintenance of such changes impacts the balance of blood sugar and control of other symptoms related with high or low blood sugar. In the present study adults with diabetes mellitus were quite aware of such lifestyle changes and ensured such several lifestyle changes in order to the balance body metabolism with fluctuations in blood sugar. Therefore follow up of such lifestyle pattern has helped participants of the present study to have least complications and a more balanced metabolism. Several studies in past have also supported the presence of lifestyle changes and their influence in diabetes management; meditation (Mathew et al., 2014), exercise (Colberg et al., 2010) presence of home remedies such as *Azadirachta indica* (Neem), *Barbadensis* (Aloe vera) etc (Pandey, Tripathi and Goswami, 2011) and proper diet management (Strychar, Elisha and Schmitz, 2012; Asif, 2014; Sami et al., 2017; Weller, Baer, Nash and Perez, 2017).

With the constant check of blood sugar (figure 7), regular visits with diabetologist (figure 8), along with the presence of meal plan (figure 9) and follow up of meal plan supplemented with home remedies and presence of regular exercise with consistent disease favored lifestyle changes (figure 12) are all essential contributors of the absence of the severe co-morbid medical conditions as present in the previous studies

(Ravishankar, Dinesh and Reddy, 2014; Kumar and Krishna, 2015). All these factors ensure a better quality of life as compared to adults with diabetes having severe co-morbid conditions as seen in the previous studies. Therefore in the present study, these all factors together contribute to the presence of quite similar quality of life to the adults without diabetes mellitus.

Another component essential in management of diabetes is medication and follow up with it. Previous studies have also emphasized on the influence of the medical adherence and influence on management of blood sugar levels (Zulling et al., 2015). In the present study, 64% of adults with diabetes mellitus are very regular with their medications. This further contributes to the presence of the moderately better awareness of the self management compared to the sample of some of the previous studies (Solanki, Dubey and Munshi, 2009).

Using MANOVA and Pearson Moment Correlation, a statistical analysis was conducted for studying the objectives of the present study, along with testing the possible hypothesis under respective objectives, determining the presence of effect of neuropsychological functioning, depression and quality of life with the absence and presence of diabetes mellitus.

A two-way MANOVA was conducted with all the three variables, neuropsychological functioning, depression and quality of life, a statistically significant interaction effect among adults with diabetes mellitus and matched healthy individuals was found. This indicated the presence of effect of diabetes mellitus type II on neuropsychological functioning, depression and quality of life.

The total neuropsychological functioning between the group of adults with diabetes mellitus and matched healthy individuals was also significantly different, which is in line with the hypothesis 1. This indicated that diabetes mellitus significantly affects the neuropsychological functioning of the adults,

which is similar to the findings of the previous studies (Watari et al., 2006; Solanki, Dubey and Munshi, 2009; Sarfo and Kole, 2014).

Under the components of the neuropsychological functioning, there was significant difference in attention, sustained attention, working memory, cognitive flexibility, mental speed, category fluency, phonic fluency and response inhibition, which is very similar to the previously reviewed studies where such executive functions have been significantly impaired as an influence of diabetes mellitus (Ren et al., 1990; Reaven et al., 1990; Jagusch et al., 1992; Strachen et al., 1997; Ryan et al., 2000; Augustina et al., 2005; Jagusch et al., 1992; Solanki et al., 2009; Watari et al., 2006; Takeuchi et al., 2012).

The two components were not found to be significant, verbal learning and memory and visual construction and visual learning and memory. Unlike the present study, previous research showed comparable significant difference on visual learning and memory (Watari et al., 2006; Solanki et al., 2009; Takeuchi et al., 2012).

Along with the above, neuropsychological functioning had a positive correlation with blood glucose (FPG) level, though non-significant but in the expected direction in line with previous studies (Solanki et al., 2009). Similarly a non-significant positive correlation was present between the neuropsychological function and hemoglobin level.

As discussed, the role of onset age and presence of co-morbid medical conditions are contributing the impairment in an individual's neuropsychological functioning (Wilmot and Ildris, 2014). Similarly in the present study, along with onset age of diagnosis and co-morbid medical condition, blood glucose level and hemoglobin level have collectively impacted the presence of significant impairment in the neuropsychological functioning of the adults with diabetes mellitus type 2.

In the present study, the prevalence rate of depression was similar among adults with diabetes mellitus (93%) and matched healthy individuals (97%), indicating no significant difference. Previously reviewed studies, have shown prevalence of severe depression among adults with diabetes mellitus (Andreoulakis et al., 2012; Thour, Das, Sehrawat and Gupta, 2016; Derakhshanpour et al., 2015, Watari et al., 2006).

In the present study, among the adults with diabetes mellitus presence of self regulation of medicine with regular adherence, comparably better health behavior maintains the fair control on perceived self care failure leading to presence of consistent motivation for self-management of their illness. The perceived self – care failure has shown to increase the burden and decrease the motivation for self management of the chronic illness (Chew, Ghazali and Fernandez, 2014). These are the factors responsible in the treatment of balancing the blood glucose level and maintenance of the autonomous nervous system activities (figure 2), which further moderates the impact on adults with diabetes mellitus leading to decrease in burden comparably with matched healthy individuals. Therefore there is no addition of perceived self care burden and failure contributing to the absence of significant difference in depression among adults with diabetes mellitus.

The total quality of life between the group of adults with diabetes mellitus and matched healthy individuals were not found to be significant, hence accepting the third hypothesis. This indicates that diabetes mellitus did not significantly affect the total quality of life of the adults in the present study, which is in contrast to the findings of the previous studies (Mathew, Gireesh et al., 2014; Kumar and Krishna, 2015; Odili, Ugboka and Oprah, 2008; Derakhshanpour, Vakili, Farsinia and Mirkarimi, 2015).

Previous studies have shown a direct impact of diabetes mellitus on quality of life, but it varies a lot with several other contextual factors, like absence of information (Kiadaliri et al., 2013), awareness about lifestyle management (Mathew

et al., 2014) etc. There is presence of significant symptom control and self management practices, along with the awareness of its importance (figure 2) in the present sample of adults with diabetes mellitus which contributes to the no significant difference in quality of life in comparison with adults with matched healthy individuals.

Also due to the government employability, presence of almost all the medical facilities without extensive financial affordability reduces the burden of health care costs and increases the feasibility of the health care services (figure 3). This further increases the quality of life and makes it almost similar to the matched healthy individuals with no significant difference (table 18).

Along with the prevalence rate of total depression (table 13), the nature of the co-morbid medical conditions (table 4) also contributes to no significant difference in quality of life among adults with diabetes mellitus and matched healthy individuals. In the group of adults with diabetes mellitus, not a single participant had any obvious end stage complication which has been shown to be a significant factor for the greatest perceived burden among the adults with diabetes mellitus (Peek et al., 2007). Therefore, presence of least severe co-morbid condition along with moderate and low depression can enhance the quality of life of adults with diabetes mellitus (figure 2).

Among the four components of the quality of life, there was significant difference in physical quality of life, Whereas, rest three components, psychological quality of life, social quality of life and environmental quality of life were not significantly different between the groups of adults with diabetes mellitus and matched healthy individuals. Similarly Derakhshanpour, Vakili, Farsinia and Mirkarimi (2015) also found a significant difference in physical quality of life along with the two other components that is psychological and environmental quality of life.

The significant difference in the physical quality of life component could also be the possible result of the presence of physical symptoms, requirement of the medical treatment to live similar quality of life of matched healthy individuals and for being able to satisfactorily complete their work and daily activities of living.

The relationship between neuropsychological functioning, depression and quality of life among adults with diabetes mellitus were not significant but were found in the expected directions. There was a positive correlation between total neuropsychological functioning and quality of life, indicating better neuropsychological functioning with higher quality of life among adults with diabetes mellitus.

A negative correlation was found between depression and neuropsychological functioning similar to the findings of Solanki, Dubey and Munshi (2009), indicating increase/improvement in neuropsychological functioning with decrease in depression level among adults with diabetes mellitus. Quality of life and depression also shared a negative correlation, therefore an increase in depression will imply a decrease in

quality of life among adults with diabetes mellitus.

Overall, neuropsychological functioning were found to significantly different due to alterations in the physical aspects of the body like blood glucose level, hemoglobin level and is determined more scientifically, similar to the previous research findings.

Though there wasn't any significant difference present for depression and quality of life compared to previous studies. Depression and quality of life are social constructs which varies a lot with the nature of the complications, management of symptoms, medical adherence, lifestyle practices, acceptance, co-morbid medical conditions and so on (figure 2). Therefore, these factors and such aware nature of participants for the diabetes as a disease and its treatment procedures seem to a possible influence for the non- significant difference in depression and quality of life in the present study. Apart from the awareness among the participants, there is also presence of a supportive and protective environment with the medical facilities and co-operative work environment.

Figure 17: Summary Model

A summarized model was prepared representing the findings of the present study indicating the predictors and relationships between the variables and themes. Looking into the biological factors, impairment in the blood glucose level leads to diabetes mellitus. This impairment further affects the hemoglobin level leading to increase severity with diabetes mellitus. There are certain co-morbid conditions which are result of diabetes mellitus and also further impair the maintenance of the diabetes. Duration of illness also affects the presence and severity of the co-morbid medical conditions. Along with the duration, onset of the illness also influences the co-morbid medical conditions. Presence of an early onset increases chances of more co-morbid medical conditions.

All these biological factors collectively impair the neuropsychological functioning of the individual. In the present study, attention, executive function, working memory and response inhibition are significantly affected neuropsychological functions. Impairment in blood glucose level and hemoglobin impairs the polyol pathway activation and glycation process, which further decreases the neuropsychological functioning of the individual. This process gets influenced with the co-morbid medical conditions, history of substance use and absence of any end stage complication in the present study.

Depression as discussed above is a social construct which is influenced with the presence of burden in the adults with diabetes mellitus. The predictors of this burden are the self regulation of medical treatment and self care failure perception. In the present study level of depression wasn't significantly different from the matched healthy individuals because of the presence of control on their self care and management of their medical treatment. These predictors are further influenced with increase in the co-morbid medical conditions and complication affecting the existing burden, along with the presence of end stage complication.

Quality of life among adults with diabetes mellitus is determined by the motivation for the self – management along with the presence of supportive environment. The predictors of this motivation are influenced with the medical treatment adherence, health care costs, symptoms control and familiarity with illness. Along with these the major factor that influences this motivation is lifestyle changes. A preventive lifestyle decreases the severity of co-morbid medical conditions and decreases the self care failure perception which collectively reduces the burden and decreases the depression level and instead increases the motivation of self management and further influences the quality of life. A preventive lifestyle includes meal plan, alternate home remedies, engagement with regular physical exercise and meditation.

Conclusion

The chronic nature of the diabetes as an illness influences the behaviour, burden and quality of the life of an individual. Presence of diabetes with the unfavorable environmental conditions and improper regulation with medicines makes it the host of multiple psychological problems. Like in the present study, the presence of depression and diabetes burden will worsen their medical outcomes. Therefore, all the above factors collectively affect the medical outcomes, neuropsychological functioning and mental health of the adults with diabetes mellitus.

Comparing the outcomes of diabetes on adults with diabetes mellitus in the present study with previously reviewed studies, it can be clearly seen that there is requirement of the supportive and caring environment, presence of preventive lifestyle and some psychological interventions for the regulating the affect on their mental health like depression and burden. Apart from regulating the depression level and burden, enhancement of neuropsychological functioning is also important for the maintenance of the daily living.

To conclude, neuropsychological functioning, depression does affects quality of life of an adult

with diabetes mellitus, in consideration with influence of self management practices and awareness about the diabetes mellitus type II.

Looking at the data obtained in the present study, interventions are required by medical Practitioners, Mental Health Professionals and Neuropsychologists and Public health and organization in order to have a holistic management of diabetes and have a comparable healthy living. Mental health professionals can help initiating psychosocial and behavioral interventions for reduction of mental health co-morbidities and enhancement of motivation for self – management of their diabetes in order to reduce complication and medical co-morbidities.

Limitations of the Present Study

Despite the research gaps, there are three prominent limitations of the present study. Firstly, due to paucity of time sample collected was quite small and was recruited from the immediately available environment. Secondly, cross sectional nature of the study, therefore no baseline assessments were made for any of the variables. Lastly a quantitative approach to study quality of life and depression wasn't appropriate; probably an in-depth interview would have helped providing a more rich data on perceived burden and existing quality of life.

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