Original Article

Impact of Sleep Quality on Glycemic Control in Type 2 Diabetes Mellitus

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Abstract

Background: Glycemic control is important to reduce the risk of micro - vascular problems among patients with diabetes mellitus. Sleep limitation leads to increase Hemoglobin A1C (HbA1c) levels; though, slight is known regarding the metabolic impacts of usual sleep limitation. The current study was a hospital-based cross-sectional study which performed to evaluate the association between habitual sleep quality with glycemic control and HbA1c fluctuations among contributors in the medical merjan city among Type 2 diabetics. **Objectives:** The purpose of current study is to assess sleep quality among Type 2 diabetic patients and to consider the influence of sleep value on glycemic control among those patients in Al-Hilla City. **Methods:** Our study was "descriptive cross sectional study" to assess the sleep quality using Pittsburgh Sleep Quality Index by filling out the questionnaire formats which designed for usage of the study. This study include a "convenient sample" of 150 Type 2 diabetic patients who visit the specialist day clinic in diabetic center of merjan medical hospital between the 25th of February to the end of June, 2018. Verbal approval was attained from each Type 2 diabetic patient, data collection was done through the interviewing of contributors by use of structural questionnaire. **Results:** The mean age of diabetic patients was (53.20 ± 13.53), Male represents (42.7%) and female represents (57.3%). Poor sleep quality represent (35.3%). There was a significant increase in level of HbA1c and random blood sugar among patients with Type 2 diabetics with poor sleep quality and significant decrease of cholesterol and triglycerides levels with increase duration of diabetes mellitus. **Conclusions:** Poor sleep was common among diabetic patients. There is close association between sleep quality and glycemic control, as well as short sleepers have an increased occurrence of diabetes.

Keywords: Diabetes mellitus, hemoglobin A1C, pittsburgh sleep quality index

Introduction

Diabetes mellitus (DM) can be defined as a group of metabolic complaints described by hyperglycemia resultant from deficiencies in insulin secretion, action, or both.[1]

A number of pathogenic processes are shared in the progress of diabetes; these array from autoimmune damage of the β-cells of the pancreas with subsequent insulin insufficiency to aberrations that give rise to resistance to insulin action.[1] As a result of deficiency of insulin action on target tissues besides hyperglycemia there will be abnormalities of fat, protein and carbohydrate metabolism, producing diabetes typical clinical features, macro and-microvascular problems in addition to amplified risk of cardiovascular disease (CVD).[1] There are four types of DM[2] which identified by new classification system: Type 1, Type 2, "other specific types" and gestational diabetes.[3,4] There is expectations that The total number of diabetic people will increase from 171 million in 2000 to 366 million in 2030, with China, India, and USA being the top 3 countries projected to have the uppermost records of people with DM.[5] In all over the world, the diabetes epidemic is attributable to the rise in prevalence of obesity, related to "westernized" routine, specifically variations in nutritional behaviors, with amplified consumption of refined sugars, saturated fats and alcohol, and decreased eating fibers, and simultaneously, decline in physical activity.[6] Manifold shapes of proof support the opinion that genetic components acting a significant part in the pathogenesis of Type 2 DM.[7] The nearly 4-fold increased risk for Type 2 DM in siblings of a diabetic parents compared with the general population support the

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opinion of genetic role, so, the odds ratio (OR) of 3.4–3.5 with a single affected parent, besides the rise in the OR to 6.1 if parents together are affected.[8] The relationships concerning environmental and genetic factors in the progress of Type 2 diabetes can be intricate. Beginning of β-cell impairment or other metabolic defects can be due to environmental factors, whereas genes may control the rate of development to explicit diabetes; certainly, in a number of cases environmental factors depend on genetic factors to start processes that lead to the progress of the disease.[9] Type 2 diabetes which accounts for 85%–95% of all diabetes often remains undiagnosed for several years because of asymptomatic period of sub-clinical phases.[10] The typical symptoms of diabetes for instance polydipsia, polyuria, and polyphagia arise usually in Type 1 diabetes, that consumes a fast progress to severe hyperglycaemia and similarly in Type 2 diabetes with identical high levels of hyperglycaemia. One of the most common signs of Type 1 diabetes is sever weight loss which can occur in Type 2 diabetes whene remains undetected for a long period. Unexplained weight loss, restlessness, fatigue and body pain are too common signs of latent diabetes. Mild symptoms or that have slow progress might similarly persist unobserved.[11,12] Diagnosis of diabetes can be depended on plasma glucose (PG) criteria or Hemoglobin A1C (HbA1c) criteria, either the 2-h PG level after a 75-g oral glucose tolerance test or the fasting PG.[2,13] Diabetes can be prevented primarily by some schemes for instance lifestyle amendment that are made known to be effective in people of different ethnicity.[14,15]

Sleep quality and quantity are related to an augmented possibility of cardiovascular morbidity but then correspondingly with increased risk of mortaliy.[16,17] Type 2 diabetic subjects have reported more sleep problems than nondiabetic as results from Sleep Heart Health study; on the other hand, there is no strong evidence whether diabetes have caused central sleep disturbances or whether these disturbances may exactly be in connection with special effects of diabetic complications.[18]

Sleep apnoea and habitual snoring which are symptoms of a group of disorders recognized as sleep-disordered breathing are related to abnormal insulin values and fasting glucose readings independent of body mass index (BMI) and age, was indicated by other cross sectional studies,[19,20] Moreover, habitual snoring is related to more than a twofold danger of evolving Type 2 diabetes over a 10-year period sovereign of age, BMI and other variables that was shown by prospective data from the Nurses Health Study[21] and a population-based Swedish study.[22]

Lately, in the Nurses Health Study it was revealed that sleeping fewer than 6 h was related to a more threat of occurrence of Type 2 diabetes in females.[23] A connotation between sleep disorders and occurrence of Type 2 DM possibly will have excessive community health consequences, from the time when sleep complaints are becoming progressively communal and are upsetting oodles of folks.[24]

Medical study has revealed that about one third of subjects with diabetes complain from associated sleep disturbances, as compared with 8% of controls without diabetes.[25] In other research, conducted at University of Pittsburg has been shown that more than 50% of Type 2 diabetics are reported to be "poor sleepers." There is strong correlation between sleep disorders and insulin resistance, that were shown in obese people.[26] Regarding diabetes control; some of demographic features such as gender, age, education, are not concomitant with problems of diabetes control, but the patients who are reported as "poor sleepers" are found to have problems in diabetes control.[27]

One of the numerous factors that lead to sleep disturbance is nocturnal hypoglycemia which is considered as leading cause to poor sleep quality amongst diabetic patients.[28]

Materials and Methods

This study was done to assess the relationship between sleep quality and glycemic control among Type 2 diabetic patients. This study was carried out in the diabetic center of merjan medical hospital, in Babylon province. The sample of study was collected from diabetic patients visit that center.

This study included a convenient sample of 150 patients with Type 2 DM who visit the specialist day clinic in diabetic center of merjan medical hospitalwho agreed to participate in the study.

This study was descriptive cross sectional study to assess the sleep quality using Pittsburgh Sleep Quality Index (PSQI) by filling out the questionnaire formats which designed for purpose of the study. Questionnaire formats consist of the first part sociodemographic characteristics include (age, BMI, level of education, occupation, residence, habit of smoking), medical history, (history of ischemic heart disease, congestive heart failure, cerebrovascular accident (CVA), nocturnal hypoglycemia, duration of DM, type of treatment, history of hypertension and if the patient is continued on medication for the treatment of hypertension, history of renal disease, ophthalmological history), about the management of diabetic foot and continuous ophthalmological examination. Second part of questionnaire formats consist of questions related to PSQI score which is standard measure to assist sleep quality among diabetic patients.

The PSQI is a score consisting of nine questions which evaluate different factors correlated to sleep quality in the preceding month. "The nine questions" were divided into "seven component scores," each one put on a "0–3 scale." "The seven components" were at that time collected to produce a "global PSQI score (range: 0–21);" greater scores point to inferior sleep quality. The components of the PSQI are: "Subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medications and daytime dysfunction." In agreement to Buysse *et al*., patients with a PSQI score <5 were defined as "good sleepers." Accordingly, in this study design, a PSQI score 5–8 was defined as "average sleep quality" and a PSQI score >8 was defined as "poor sleep quality" (Tsai *al*., 2011). The duration of the study started from the end of February, 2018 to end of June, 2018.

Table 1: The distribution of diabetic patients according to study variables

Study variables	*n* (%)
Age (years)	53.20±13.53 (18-82)
Gender	
Male	64 (42.7)
Female	86 (57.3)
Total	150 (100.0)
Residence	
Urban	118 (78.7)
Rural	32 (21.3)
Total	150 (100.0)
Educational level	
Illiterate	30 (20.0)
Primary	60 (40.0)
Secondary	30 (20.0)
Higher education	30 (20.0)
Total	150 (100.0)
Occupation	
House wife	75 (50.0)
Employee	26 (17.3)
Free work	20 (13.4)
Retired	29 (19.3)
Total	150 (100.0)
Marital status	
Married	119 (79.3)
Single	10 (6.7)
Widow	18 (12.0)
Divorce	3 (2.0)
Total	150 (100.0)
BMI	
Obese ≥30	64 (42.7)
Preobese (25-29.9)	51 (34.0)
Normal (18.5-24.9) or underweight <18.5	35 (23.3)
Total	150 (100.0)
Smoking habit	
Smoker	23 (15.3)
X-smoker	24 (16.0)
Nonsmoker	103 (68.7)
Total	150 (100.0)

BMI: Body mass index

Ethical approvals

Acceptance was obtained from scientific committee in the department of community medicine in college of Medicine - University of Babylon. Verbal consents were obtained from the patients prior to interviewing after explaining of the aim of the study.

Inclusion and exclusion criteria

Any Type 2 diabetic patient who visit merjan diabetic clinic during the time of data collection was included in the study and any patient refuses to participate in the study, patients with connective tissue disease and any patients who were diagnosed with sleeping disorder and on treatment were excluded from the study.

Table 2: The mean differences of study variables according to sleep quality

Study variables	Sleep quality	*n*	Mean±SD	*F*	*P*
HBA1C (%)	Good (<5)	34	7.17±2.15	3.098	0.048*
	Average (5-8)	63	8.34±2.55		
	Poor (>8)	53	8.07±1.82		
RBS (mg/dl)	Good (<5)	34	193.52±84.21	3.22	0.043*
	Average (5-8)	63	234.33±102.70		
	Poor (>8)	53	250.23±113.08		
Cholesterol (mg/dl)	Good (<5)	34	178.04±41.72	0.505	0.604
	Average (5-8)	63	181.08±42.13		
	Poor (>8)	53	187.56±53.06		
Triglyceride (mg/dl)	Good (<5)	34	111.31±39.08	1.726	0.181
	Average (5-8)	63	130.31±72.71		
	Poor (>8)	53	133.74±45.96		

HBA1C: Hemoglobin A1C, RBS: Random blood sugar, SD: Standard deviation, *($P \leq 0.05$) was considered significant

Data analysis

The statistical analysis was performed using Statistical Package for the Social Sciences version 20 (SPSS, IBM Company, Chicago, USA). Categorical variables were presented as frequencies and percentages. Continuous variables were presented as (means ± standard deviation). Independent sample *t*-test was used to compare means between two groups. ANOVA test was used to compare means between three groups or more. Pearson Chi-square and Fisher's-exact test were used to find the association between categorical variables. A $P \leq 0.05$ was considered as significant.

Results

The mean age of diabetic patients was (53.20 ± 13.53), Male represents (42.7%) and female represents (57.3%) as shown in Table 1. Poor sleep quality represent (35.3%) as shown in Figure 1. The study found that (65.3%) of diabetic patient presented with poor glycemic control (HbA1C > 7) as shown in Figure 2. There was a significant increase in level of HbA1c and RBS among patients with type 2 diabetes with poor sleep quality as shown in Table 2. There were significant associations between sleep quality and duration of diabetes and between sleep quality and heart failure as shown in Table 3. There was significant decrease of cholesterol and triglycerides levels with increase duration of D.M as shown in Table 4. Figure 3 show the mean differences of hours of actual sleep of diabetic patients according to sleep quality score , there were significant differences between means of hours of actual sleep by sleep quality score ($P < 0.001$*).

Discussion

Our cross-sectional study which was done on Type 2 diabetic patients in Al-Hilla city mean age was (53.20 ± 13.53) years (range 18–82), (42.7%) male and (57.3%) female, 42.7% of them were obese, 51.3% of them with history of hypertension,

Table 3: Association between sleep quality and study variables

Study variables	Sleep quality			χ^2	*P*
	Good	Average	Poor		
Hypertension					
Yes	14 (41.2)	33 (52.4)	30 (56.6)	2.021	0.364
No	20 (58.8)	30 (47.6)	23 (43.4)		
Total	34 (100.0)	63 (100.0)	53 (100.0)		
IHD					
Yes	10 (29.4)	15 (23.8)	19 (35.8)	2.013	0.366
No	24 (70.6)	48 (76.2)	34 (64.2)		
Total	34 (100.0)	63 (100.0)	53 (100.0)		
Cerebrovascular accident					
Yes	6 (17.6)	6 (9.5)	5 (9.4)	1.744	0.418
No	28 (82.4)	57 (90.5)	48 (90.6)		
Total	34 (100.0)	63 (100.0)	53 (100.0)		
Heart failure					
Yes	2 (5.9)	4 (6.3)	11 (20.8)	7.244	0.027*
No	32 (94.1)	59 (93.7)	42 (79.2)		
Total	34 (100.0)	63 (100.0)	53 (100.0)		
Renal diseases and recurrent UTI					
Yes	15 (44.1)	26 (41.3)	30 (56.6)	2.897	0.235
No	19 (55.9)	37 (58.7)	23 (43.4)		
Total	34 (100.0)	63 (100.0)	53 (100.0)		
Hypoglycemia					
Yes	12 (35.3)	25 (39.7)	21 (39.6)	0.211	0.9
No	22 (64.7)	38 (60.3)	32 (60.4)		
Total	34 (100.0)	63 (100.0)	53 (100.0)		
Duration of DM (years)					
<10	14 (41.2)	28 (44.4)	11 (20.8)	9.853	0.043*
10-20	14 (41.2)	30 (47.6)	31 (58.5)		
20 or more	6 (17.6)	5 (7.9)	11 (20.8)		
Total	34 (100.0)	63 (100.0)	53 (100.0)		
Visual disturbance					
Yes	26 (76.5)	56 (88.9)	46 (86.8)	2.86	0.239
No	8 (23.5)	7 (11.1)	7 (13.2)		
Total	34 (100.0)	63 (100.0)	53 (100.0)		
Type of treatment					
Diet control	0 (0.0)	3 (4.8)	0 (0.0)		0.008*f
OHA	7 (20.6)	23 (36.5)	9 (17.0)		
Insulin	22 (64.7)	26 (41.3)	24 (45.3)		
Insulin, OHA and diet	5 (14.7)	11 (17.5)	20 (37.7)		
Total	34 (100.0)	63 (100.0)	53 (100.0)		

*$P \leq 0.05$ was significant, Fisher-exact test. IHD: Ischemic heart disease, DM: Diabetes mellitus, UTI: Urinary tract infections, OHA: Oral hypoglycemic agent

31.3% were smokers or X-smokers and 11.3% had history of CVA while 29.3% with history of CVD, 11.3% with heart failure and 47.3% of them had history of renal diseases and recurrent attacks of urinary tract infections. Other study in Egypt[29] showed that the females were the preponderance of the study group which reveals the information that the females presence to "family medicine outpatient clinic" is greater than males.

In other study in Taiwan[30] similar results was found among diabetic patients there were 61% men and 39% women, mean age was 60.1 ± 9.7 years, they had 67% obese and 63% hypertension, they had 46% good glycemic control and 54% poor glycemic control which was similar to our study we had 34.7% good glycemic control and 65.3% poor glycemic control. In another study done in America[31] included 48.6% men 51.4% women the mean age was 70.2 years (range 53–93 years) which is more than mean age of our study (53.20 ± 13.53) years.

As HbA1c is supposed to reproduce usual blood sugar for a number of months[32] and has robust predictive value for complications of DM[33,34] we considered A1c level as the directory for glycemic control in our patients.

The level of HbA1C of <7% is well-defined as good glycemic control founded "on the American Diabetes Association 2010

Table 4: The mean differences of study variables according to duration of diabetes mellitus

Study variables	Duration (years)	*n*	Mean±SD	*t*	*P*
HBA1C (%)	<20	128	8.07±2.29	1.22	0.224
	20 or more	22	7.44±2.01		
Cholesterol (mg/dl)	<20	128	185.99±46.10	2.144	0.034*
	20 or more	22	163.46±41.73		
Triglyceride (mg/dl)	<20	128	131.11±60.14	2.006	0.047*
	20 or more	22	104.57±35.83		

*$P \leq 0.05$ was considered significant. HBA1C: Hemoglobin A1C, SD: Standard deviation

Guidelines" though the level of HbA1c of ≥7% is defined as poor glycemic control. We found that 34.7% of diabetic patients with HbA1C <7%, and 65.3% of them with HbA1c >7%. In this study, we found a strong and significant relationship between the level of HbA1c and sleep quality, the same relationship between random blood sugar and sleep quality.

One study piloted in Italy on the connotation of sleep irregularities of DM and the levels of PG[35] its conclusions was that low sleep maintenance ($P = 0.002$) besides sleep efficiency ($P = 0.005$) in Type 2 diabetics. HbA1C level interrelated contrariwise with sleep efficiency ($r = 0.29$), ($P = 0.047$). These findings propose that good sleep efficiency was related to low level of HbA1C and that is similar to the results of our study ($P \leq 0.048$).

Other study in Taiwan[30] which showed that there was significant association between sleep efficiency and HbA1c ($P = 0.002$), and significant association between sleep quality and HbA1c ($P = 0.05$). These findings propose that low sleep efficiency and quality are strongly associated with poorer glycemic control in patients with Type 2 DM and this is in agreement with the results of our study.

In this study we found that patients with heart failure who had good sleep quality (5.9%), average sleep quality (6.4%), poor sleep quality (20.8%) and there was significant association between sleep quality and heart failure, ($P = 0.027$). This finding agree with study in Netherlands[36] which showed that those with poor sleep quality and short sleep duration had a 63% increasing threat of CVD occurrence and an 79% increasing threat of coronary heart disease (CHD) occurrence and subsequent heart failure, and persons with long sleep duration did not have more risk of CHD or CVD occurrence. Patient with heart failure usually complain from shortness of breath especially during night so this will effect sleep quality and subsequent development of Type 2 DM.[37,38]

In our study we found that the minority of diabetic patients (only 22.7%) were presented with good sleep quality (score <5) and 42% with average sleep quality (score 5–8) and 35.3% with poor sleep quality (score > 8) nearly the same results of other study in Taiwan[30] in which there were 34.8% with poor sleep quality. In other study in Saudi Arabia[39] about assessment of sleep quality, — (74.2%) of study group had poor sleep quality.

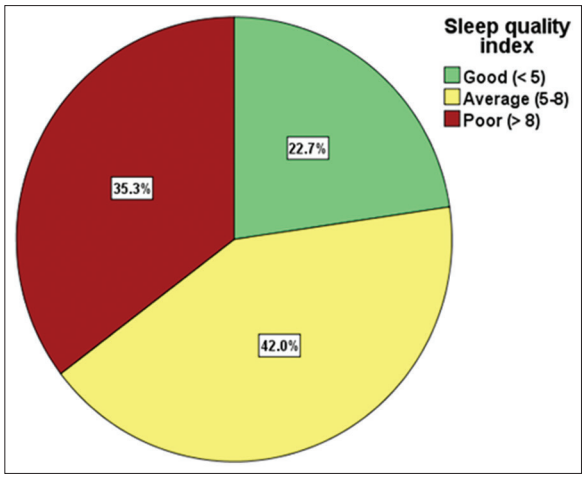

Figure 1: Distribution of diabetic patients according to sleep quality

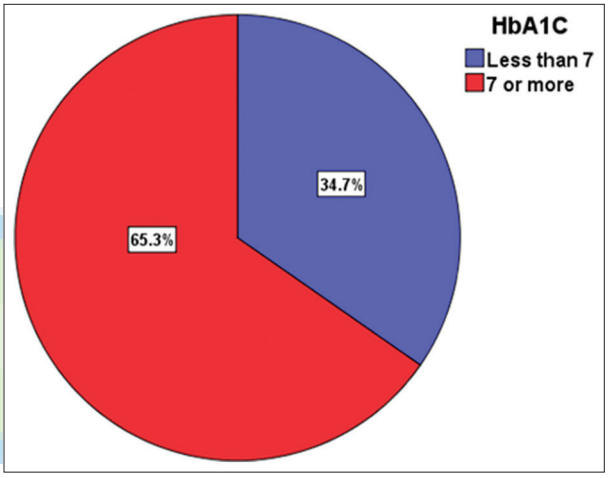

Figure 2: Distribution of diabetic patients according to glycaemic control

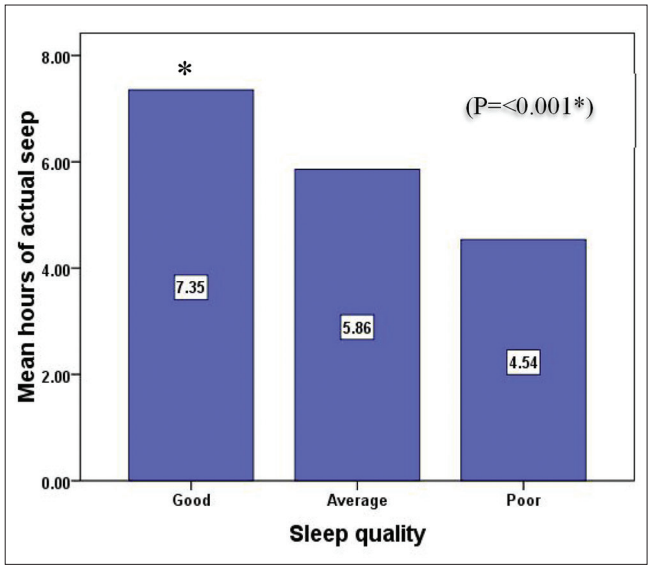

Figure 3: Mean differences of hours of actual sleep of diabetic patients according to sleep quality score ($P = <0.001$*)

This study was consistent with previous studies showing correlation between short sleep duration and increase risk of diabetes.[31,40,41] In another study in Taiwan[42] exhibited that group of diabetic patients with sleep duration <5 h showed OR of diabetes prevalence (2.04 doubling more than the control group) with a duration of sleep about 7 h–8.9 h. Other study in Iran[43] showed that sleep duration of ≤5 h in people below the age of 60 was related to higher risk of DM and impaired glucose tolerance (IGT).

Well-known laboratory readings advised that poor sleep influenced utilization of blood glucose and regulation of insulin.[24,44] Previous physiological studies reinforced the classic that short sleep duration up-controls the activity of "the hypothalamic–pituitary–adrenal axis" and stimulates the cortisol secretion.[24]

A preceding study proposed that sleep with short duration augmented the possibility of IGT.[45] Our data showed that the diabetic persons with poor sleep quality were with higher random blood glucose levels and significant correlation between RBS and poor sleep quality $P = 0.043$; So, in upcoming studies, variations in the levels of blood glucose could be checked for extended periods of time in members with characteristic short durations of sleep. Otherwise, long-standing sleep style could be assessed in members with abnormal levels of blood glucose to control the diabetes risk.

In another study in Taiwan,[42] members with duration of sleep ≤5 h exhibited a high tendency for sleep disorders, which was 63.4%.[31,46] So, fluctuations in sleep duration and sleep quality could be a prognosticator of progress of DM.[41]

In our study the patients with poor sleep quality had mean actual sleep 4.54, those with average sleep quality had 5.86 mean actual sleep, and those with good sleep quality had 7.35 mean actual sleep and there were significant differences between means of hours of actual sleep by sleep quality score ($P = 0.001$). In other study in Saudi Arabia[39] elevated "mean sleep quality scores (PSQI) (mean = 10.50)" were experiential in those with low sleep quality, and sleep disturbance was foreseen by sleep conducts such as duration of sleep of about <7 h. By 2002, the adult "median sleep time" had lessened to 7 h each night, with extra 1/3 of adults sleeping <7 h.[47]

Numerous studies have showed that elevated mortality related to typical sleep times of <7 each night in California.[16,48] Investigational limit of sleep to 4 h each night for 6 nights led to IGT in well young adults.[24]

In our study we found that there is improvement of the level of lipid profile (cholesterol and triglyceride) with more duration of DM as shown in Table 4 which were mean of cholesterol level of diabetic patients with duration of <20 years was (185.99) but the mean of diabetic patients with duration of more than 20 years was (163.46), ($P = 0.034$) and the mean of triglyceride for diabetic patients with duration of <20 years (131.11) and the mean of patients with more than 20 years duration (104.57) for triglyceride; ($P = 0.047$). This can explained by that patients with short duration of DM have less experience regarding risk factors associated with poor glycemic control including poor diet habit and sedentary life style and those patients with longer duration have more experience regarding using treatment and regular follow up. This results agree with other study in adults found that longer duration of diabetes and more education and more experience of patients lead to better sugar control by about 20%, moreover the triglecirides and total cholesterol were well controlled by about 30%.[49]

The absence of education and practice concerning risk factors and treatment use to reach standard levels of blood sugars is the leading cause for uncontrolled Type 2 diabetes. There is necessity to educate diabetic people to attain satisfactory control. In latest years, there was improvement of management of dyslipidemia in diabetics and additional hard work is necessary.[50]

Lifestyle interferences such as weight loss, diet, smoking stop and physical activity are an essential measure of every strategy for management of diabetes. Epidemiologic studies have revealed significant perfection 0f the signs and symptoms of dyslipidemia in diabetic people with physical activity and medicinal nutrition treatment.[51,52]

Conclusions

Poor sleep quality was common among Type 2 diabetic patients. Majority (65.3%) of diabetic patients presented with poor glycemic control HbA1c (7 or more). This study shows close association between sleep quality and glycemic control among Type 2 diabetic patients, also short sleepers have an increased incidence of DM.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Malecki MT, Klupa T. Type 2 diabetes mellitus: From genes to disease. Pharmacol Rep 2005;57:20-32.
2. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care 2014;37 Suppl 1:S81-90.
3. Report of the expert committee on the diagnosis and classification of diabetes mellitus. Diabetes Care 1997;20:1183-97.
4. National Diabetes Data Group. Diabetes in America. 2nd ed. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, NIH Publication; 1995.
5. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030. Diabetes Care 2004;27:1047-53.
6. Schulz LO, Bennett PH, Ravussin E, Kidd JR, Kidd KK, Esparza J, *et al.* Effects of traditional and western environments on prevalence of type 2 diabetes in Pima Indians in Mexico and the U.S. Diabetes Care 2006;29:1866-71.
7. Das SK, Elbein SC. The genetic basis of type 2 diabetes. Cellscience 2006;2:100-31.
8. Meigs JB, Cupples LA, Wilson PW. Parental transmission of type 2 diabetes: The Framingham offspring study. Diabetes 2000;49:2201-7.
9. Zimmet P, Alberti KG, Shaw J. Global and societal implications of the diabetes epidemic. Nature 2001;414:782-7.

10. International Diabetes Federation. IDF Diabetes Atlas. 6th ed. Online version of IDF Diabetes Atlas: 2013. p. 7. Available from: http://www.idf.org/diabetesatlas. [Last accessed on 2018 Aug 03].
11. Ramachandran A, Snehalatha C, Vijay V, Wareham NJ, Colagiuri S. Derivation and validation of diabetes risk score for urban Asian Indians. Diabetes Res Clin Pract 2005;70:63-70.
12. Mohan V, Anbalagan VP. Expanding role of the madras diabetes research foundation – Indian diabetes risk score in clinical practice. Indian J Endocrinol Metab 2013;17:31-6.
13. International Expert Committee. International expert committee report on the role of the A1C assay in the diagnosis of diabetes. Diabetes Care 2009;32:1327-34.
14. Alberti KG, Zimmet P, Shaw J. International diabetes federation: A consensus on type 2 diabetes prevention. Diabet Med 2007;24:451-63.
15. Ramachandran A, Snehalatha C, Samith Shetty A, Nanditha A. Primary prevention of type 2 diabetes in South Asians – Challenges and the way forward. Diabet Med 2013;30:26-34.
16. Kripke DF, Garfinkel L, Wingard DL, Klauber MR, Marler MR. Mortality associated with sleep duration and insomnia. Arch Gen Psychiatry 2002;59:131-6.
17. Ayas NT, White DP, Manson JE, Stampfer MJ, Speizer FE, Malhotra A, *et al.* A prospective study of sleep duration and coronary heart disease in women. Arch Intern Med 2003;163:205-9.
18. Resnick HE, Redline S, Shahar E, Gilpin A, Newman A, Walter R, *et al.* Diabetes and sleep disturbances: Findings from the sleep heart health study. Diabetes Care 2003;26:702-9.
19. Jennum P, Schultz-Larsen K, Christensen N. Snoring, sympathetic activity and cardiovascular risk factors in a 70 year old population. Eur J Epidemiol 1993;9:477-82.
20. Grunstein R, Wilcox I, Yang TS, Gould Y, Hedner J. Snoring and sleep apnoea in men: Association with central obesity and hypertension. Int J Obes Relat Metab Disord 1993;17:533-40.
21. Al-Delaimy WK, Manson JE, Willett WC, Stampfer MJ, Hu FB. Snoring as a risk factor for type II diabetes mellitus: A prospective study. Am J Epidemiol 2002;155:387-93.
22. Elmasry A, Janson C, Lindberg E, Gislason T, Tageldin MA, Boman G. The role of habitual snoring and obesity in the development of diabetes: A 10-year follow-up study in a male population. J Intern Med 2000;248:13-20.
23. Ayas NT, White DP, Al-Delaimy WK, Manson JE, Stampfer MJ, Speizer FE. A prospective study of self-reported sleep duration and incident diabetes in women. Diabetes Care 2003;26:380-4.
24. Spiegel K, Leproult R, Van Cauter E. Impact of sleep debt on metabolic and endocrine function. Lancet 1999;354:1435-9.
25. Sridhar GR, Madhu K. Prevalence of sleep disturbances in diabetes mellitus. Diabetes Res Clin Pract 1994;23:183-6.
26. Cizza G, Piaggi P, Lucassen EA, de Jonge L, Walter M, Mattingly MS, *et al.* Obstructive sleep apnea is a predictor of abnormal glucose metabolism in chronically sleep deprived obese adults. PLoS One 2013;8:e65400.
27. Chasens ER, Korytkowski M, Sereika SM, Burke LE. Effect of poor sleep quality and excessive daytime sleepiness on factors associated with diabetes self-management. Diabetes Educ 2013;39:74-82.
28. Bode BW, Schwartz S, Stubbs HA, Block JE. Glycemic characteristics in continuously monitored patients with type 1 and type 2 diabetes: Normative values. Diabetes Care 2005;28:2361-6.
29. Abd El Latif F, Abd El Wahid HA, Mohamed A, Frag HK. Quality of life of type 2 diabetic patients in relation to gender and socio-economic status in Egypt. Int J Pharma Sci Sci Res 2016;2:152-60.
30. Tsai YW, Kann NH, Tung TH, Chao YJ, Lin CJ, Chang KC, *et al.* Impact of subjective sleep quality on glycemic control in type 2 diabetes mellitus. Fam Pract 2012;29:30-5.
31. Gottlieb DJ, Punjabi NM, Newman AB, Resnick HE, Redline S, Baldwin CM, *et al.* Association of sleep time with diabetes mellitus and impaired glucose tolerance. Arch Intern Med 2005;165:863-7.
32. Griffin JA, Gilliland SS, Perez G, Helitzer D, Carter JS. Participant satisfaction with a culturally appropriate diabetes education program: The Native American Diabetes Project. Diabetes Educ 1999;25:351-63.
33. Skinner TC, Cradok S, Arundel F, Graham W. Self-management education for individuals newly diagnosed with type 2 diabetes. Life style and behavior: Four theories and a philosophy. Diabetes Spectrum 2003;16:75-80.
34. Gamm LD. Advancing community health through community health partnerships. J Healthc Manag 1998;43:51-66.
35. Trento M, Broglio F, Riganti F, Basile M, Borgo E, Kucich C, *et al.* Sleep abnormalities in type 2 diabetes may be associated with glycemic control. Acta Diabetol 2008;45:225-9.
36. Hoevenaar-Blom MP, Spijkerman AM, Kromhout D, van den Berg JF, Verschuren WM. Sleep duration and sleep quality in relation to 12-year cardiovascular disease incidence: The MORGEN study. Sleep 2011;34:1487-92.
37. Hasler G, Buysse DJ, Klaghofer R, Gamma A, Ajdacic V, Eich D, *et al.* The association between short sleep duration and obesity in young adults: A 13-year prospective study. Sleep 2004;27:661-6.
38. King CR, Knutson KL, Rathouz PJ, Sidney S, Liu K, Lauderdale DS, *et al*. Short sleep duration and incident coronary artery calcification. JAMA 2008;300:2859-66.
39. Siddiqui AF, Al-Musa H, Al-Amri H, Al-Qahtani A, Al-Shahrani M, Al-Qahtani M, *et al.* Sleep patterns and predictors of poor sleep quality among medical students in King Khalid University, Saudi Arabia. Malays J Med Sci 2016;23:94-102.
40. Chao CY, Wu JS, Yang YC, Shih CC, Wang RH, Lu FH, *et al.* Sleep duration is a potential risk factor for newly diagnosed type 2 diabetes mellitus. Metabolism 2011;60:799-804.
41. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Quantity and quality of sleep and incidence of type 2 diabetes: A systematic review and meta-analysis. Diabetes Care 2010;33:414-20.
42. Lin CL, Tsai YH, Yeh MC. Associations between sleep duration and type 2 diabetes in Taiwanese adults: A population-based study. J Formos Med Assoc 2016;115:779-85.
43. Najafian J, Mohamadifard N, Siadat ZD, Sadri G, Rahmati MR. Association between sleep duration and diabetes mellitus: Isfahan healthy heart program. Niger J Clin Pract 2013;16:59-62.
44. Thomas M, Sing H, Belenky G, Holcomb H, Mayberg H, Dannals R, *et al.* Neural basis of alertness and cognitive performance impairments during sleepiness. I. Effects of 24 h of sleep deprivation on waking human regional brain activity. J Sleep Res 2000;9:335-52.
45. Chaput JP, Després JP, Bouchard C, Tremblay A. Association of sleep duration with type 2 diabetes and impaired glucose tolerance. Diabetologia 2007;50:2298-304.
46. Vgontzas AN, Liao D, Pejovic S, Calhoun S, Karataraki M, Bixler EO. Insomnia with objective short sleep duration is associated with type 2 diabetes: A population-based study. Diabetes Care 2009;32:1980-5.
47. Sleep in America Poll. Washington, DC: National Sleep Foundation; 2003.
48. Enstrom JE, Kanim LE, Breslow L. The relationship between vitamin C intake, general health practices, and mortality in Alameda County, California. Am J Public Health 1986;76:1124-30.
49. Raleigh, Greensboro. Improvement in lipid and glycated hemoglobin control among black adults with diabetes. JAMA 2007;297:257-8.
50. Greving JP, Denig P, de Zeeuw D, Bilo HJ, Haaijer-Ruskamp FM. Trends in hyperlipidemia and hypertension management in type 2 diabetes patients from 1998-2004: A longitudinal observational study. Cardiovasc Diabetol 2007;6:25.
51. Kraus WE, Houmard JA, Duscha BD, Knetzger KJ, Wharton MB, McCartney JS, *et al*. Effects of the amount and intensity of exercise on plasma lipoproteins. N Engl J Med 2002;347:1483-92.
52. Williams PT, Krauss RM, Vranizan KM, Wood PD. Changes in lipoprotein subfractions during diet-induced and exercise-induced weight loss in moderately overweight men. Circulation 1990;81:1293-304.