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Relation between sleep quality and glycemic control among type 2 diabetic patients

Original Article

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Abstract: **Objective:** To investigate the relation between sleep quality and glycemic control among type 2 diabetic patients.
Methods: Across sectional descriptive design was used; the study sample including 125 diabetic patients was recruited at diabetic clinics in Zagazig University hospitals. The interview questionnaire sheet consists of 4 parts: (1) demographic data, (2) medical history, (3) an Arabic version of the Pittsburgh sleep quality index (PSQI), and (4) glycated hemoglobin A1c (HbA1c) analysis test.
Results: The mean of sleep duration was the highest score of PSQI components, 96.8% of diabetic patients had poor sleep quality, and 90.4% of diabetic patients had poor glycemic control. A highly statistically significant relationship was found between HbA1c and sleep quality. Moreover, income, duration of disease and smoking were independent positive predictors of HbA1c level, while the female gender was a statistically significant negative predictor. Additionally, female gender and income were statistically significant independent positive predictors of PSQI score.
Conclusions: Poor sleep quality and poor glycemic control were very common among type 2 diabetic patients. There was a highly significant relation between sleep quality and glycemic control.

Keywords: *adult patients • chronic disease • diabetes • glycemic control (HbA1c) • quality • sleep • sleep problems*

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1. Introduction

Diabetes mellitus (DM) is a main public health burden with significant morbidity and mortality worldwide. Egypt is the eighth leading country regarding the prevalence of DM. In 2017, it was estimated that >8 million adults live with DM in Egypt, which represents a prevalence of almost 15%.[1]

Glycemic control is the adjustment and maintenance of blood glucose levels within the normal range and is best evaluated by glycated hemoglobin A1c (HbA1c). HbA1c is an indicator of the overall glucose level for the past 2–3 months and has been widely used as the "gold standard" for evaluating glycemic control. In people with type 2 diabetes mellitus (T2DM), glycemic control is cardinal for maintaining health and reducing the risks of diabetes complications, including retinopathy, neuropathy, and nephropathy. Glycemic control may be affected by multiple biological, psychological, and behavioral factors; sleep plays a possible role among these factors.[2]

Sleep is very crucial and can influence every facet of our daily life. Poor sleep quality also affects our health and well-being. People who sleep well have better cognitive function, good memory, healthier immune systems,

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increased attentiveness, and show better performance throughout the day. Epidemiologic studies revealed that shorter sleep duration and poor sleep quality can raise the risk of obesity and lifestyle-related diseases such as diseases of the cardiovascular system, T2DM, poor glycemic control, and poor quality of life.[3]

Previous studies have shown that diabetic patients need to have proper sleep periods to better control their diabetes because sleep is one of the most essential factors in life, and it has influences many metabolic aspects including glucose tolerance.[4]

Community health nurses should be provided health education to maintain good sleep quality such as sleeping in a quiet place and preventing drinking caffeine sources.[5] And refer any patient with sleep disturbances for treatment to achieve good glycemic control.[6]

1.1. Significance of the study

Type 2 diabetes is the most familiar type of diabetes and usually prevails in adults, which occurs when the body becomes resistant to insulin or doesn't generate enough insulin.[7] Poor sleep is significantly more common in persons with diabetes as compared to those without diabetes.[8] Sleep is important for hormone regulation, and insulin is a hormone. "In general, poor sleep plays a role in insulin resistance, which occurs when the body has difficulty using insulin to move glucose from the blood into cells." This can result in high blood glucose and poor glycemic control.[9]

1.2. Aim of the study

The present study aimed to investigate the relation between sleep quality and glycemic control among type 2 diabetic patients.

This aim has been attained through the following objectives:

(1) Identify sleep quality among type 2 diabetic patients.
(2) Determine HbA1c level among type 2 diabetic patients.
(3) Explore the relation between sleep quality and glycemic control among type 2 diabetic patients.

1.3. Research questions

(1) What is the sleep quality among type 2 diabetic patients?
(2) What is the HbA1c level among type 2 diabetic patients?
(3) Is there a relation between sleep quality and glycemic control among type 2 diabetic patients?

2. Methods

2.1. Research design

A descriptive, cross-sectional study design was used to attain the aim of the current study.

2.2. Setting

The study was carried out in a diabetic clinic at Zagazig University hospitals. This clinic is on the third floor and is composed of 2 rooms, 1 for doctors and the other for nurses, there are waiting areas in front of the diabetic clinic for patients, and work continues every day except Thursday.

2.3. Subjects

A purposive sample consisting of 125 patients with T2DM was selected according to the inclusion and exclusion criteria.

2.3.1. Inclusion criteria

- Patients with T2DM diagnosed >1 year ago
- Both genders
- Age: 25–60 years
- On the regular treatment of diabetes disease

2.3.2. Exclusion criteria

- Type1 or gestational diabetes
- Patients who had connective tissue problems (e.g. rheumatoid arthritis)
- Diabetic patients with psychiatric problems
- Patients taking altering medications (medications containing caffeine, cocaine, Amphetamine)
- Patients with other serious diseases such as cancer, severe infection, severe heart, lung, or brain disease

2.3.3. Sample size

The sample size was calculated to demonstrate a correlation coefficient of -0.3 or stronger[10] with 90% power and a 95% confidence level (CI) between the level of HbA1c and sleep quality score. Using the Open-Epi software package for sample size estimation for correlation, the required sample size is 113. This will be increased to 125 to account for a non-response rate of about 10%.

2.4. Tools of data collection

An Interview questionnaire sheet of data collection is composed of 4 parts:

Part 1: Demographic data included age, sex, education level, marital status, occupation, income, residence, etc.

Part 2: Medical data included duration of diagnosis, type of current treatment, and risk factors for diabetes such as family history, smoking, alcohol, hypertension, body mass index, and high cholesterol.

Part 3: The level of HbA1c taken from participants as an indicator of glycemic control. The level of HbA1c <7% was considered as good glycemic control while a level of HbA1c ≥ 7% was considered poor glycemic based on the American Diabetes Association 2017 Guidelines.[2]

Part 4: Pittsburgh sleep quality index (PSQI) developed by Buysse et al.[11] and an Arabic version of the PSQI, a valid and reliable self-administered questionnaire containing 19 questions that establish a wide variety of factors related to sleep quality in the last month was applied. The 19 questions were grouped into 7 component scores, The 7 components of the PSQI are: (1) subjective sleep quality, (2) sleep latency, (3) sleep duration, (4) sleep efficiency, (5) sleep disturbances, (6) use of sleeping medications, and (7) daytime dysfunction.[12]

2.5. Scoring

2.5.1. PSQI

The tool consists of 19 items from which 7 components covering different aspects of sleep are computed to produce one composite global score. These are sleep latency asking about how long it takes to fall asleep, sleep duration, habitual sleep efficiency measuring the percentage of sleep time of total bedtime, sleep disturbances, use of sleeping medication, and daytime dysfunction, in addition to overall subjective sleep quality. Each item is weighted on a 0–3 interval scale, with a higher score indicating worse quality. The global PSQI score is then calculated by totaling the 7 component scores, providing an overall score ranging from 0 to 21, where lower scores denote a healthier sleep quality. For categorical analysis, the total score is dichotomized into good sleep quality (total score <5), and poor sleep quality (total score ≥5).

2.6. Preparatory phase

The researcher reviewed literature of all available books and articles in periodicals or magazines, or the internet for the study to be acquainted with the research problem and develop research tools.

2.7. Content validity

The validity of the tools was tested by a panel of 3 experts from nursing faculty staff who reviewed the tools and ascertained clarity, relevance, comprehensiveness, and understandability.

2.8. Reliability

To assess the reliability of the PSQI scale, the researcher used a pilot study to determine consistency by calculating Cronbach's α which showed a satisfactory level of reliability was 0.7.

2.9. A pilot study

About 12 diabetic patients (10%) were enrolled in a pilot study to test any ambiguity of questions and practicability of the tools to determine the time needed for filling questionnaire than they were rejected from the main study sample.

2.10. Fieldwork

The researcher started the collection of data through interviews with each diabetic patient individually, the average time to complete the interview questionnaire ranged from 30 min to 45 min work continued for 3 d/week: Sunday, Monday, and Wednesday from 9.00 AM to 12.00-noon Data were collected through 5 months starting from the beginning of January 2021 to the end of May 2021.

2.11. Ethical considerations

A full explanation of the purpose of the study was given to the participants and then their approval was taken orally. The researcher notified that they could withdraw at any time and were assured that any information taken from them would be kept confidential and used for the research purpose only.

2.12. Administrative design

An official letter was issued from the faculty of nursing at Zagazig University to the director of outpatient clinics by the researcher which included the aim of the research and to prove the researcher's character.

2.13. Statistical analysis

Data entry and statistical analysis were done using SPSS 20.0 statistical software package (IBM Corporation, Armonk, New York, United States). Quality control was done at the stages of coding and data entry. Data were presented using descriptive statistics in the form of frequencies and percentages for qualitative variables, and means and standard deviations (SDs) and medians were used for quantitative variables. Cronbach's

α coefficient was calculated to assess the reliability of the PSQI tool through its internal consistency. Categorical variables were compared using the chi-square test. Whenever the expected values in 1 or more of the cells in a 2 × 2 table were <5, the Fisher exact test was used instead. Quantitative continuous data were compared using the non-parametric Mann–Whitney test. Spearman rank correlation was used for the assessment of the inter-relationships between quantitative variables and ranked ones. To identify the independent predictors of PSQI and HbA1c values, multiple linear regression analysis was used and an analysis of variance (ANOVA) for the full regression models was done. To identify the independent predictors of DM control, multiple logistic regression analysis was used. Statistical significance was set at *P*-value <0.05.

3. Results

Study results reveal that 61.6% of diabetic patients' ages were >50 years with mean age ±SD 49.6 ± 8.4 and 74.4% were females and married. Concerning education, 39.2% of diabetic patients had secondary education, 54.4% of them had insufficient income, and additionally, of the 64.8% of patients diagnosed with diabetes for 5 years and more, about two-thirds of them were on oral treatment and 68.8% of patients had a family history. Additionally, 68% of them were obese and nearly half of the patients had dyslipidemia (48%).

Table 1 displays the components of the PSQI, including sleep duration, subjective sleep quality, and sleep disturbance were the highest mean score (4.0 ± 0.7, 2.5 ± 0.8, 2.4–0.6) respectively. That is to say, the higher the mean score, the poorer the quality of sleep.

Table 2 demonstrates that according to the PSQI score, 96.8% of diabetic patients had poor sleep quality ≥5. This shows that the higher the score, the poorer the quality of sleep.

Table 3 points to female gender and income that were statistically significant independent positive predictors of PSQI score and the duration of DM, oral + insulin treatment, smoking, and dyslipidemia were independent positive predictors. The regression model explains a 0.27% variation in change of this score as indicated by the *r*-square value.

Table 4 illustrates that 90.4% of diabetic patients had poor glycemic control HbA1c ≥7. This means the higher the score of 7%, the poorer glycemic control.

Table 5 illustrates that PSQI was a statistically significant independent positive predictor of HbA1c level while income, duration of DM, and smoking were independent positive predictors. The female gender was a statistically significant independent negative predictor of

Sleep (PSQI)	Mean ± SD	Median
Subjective sleep quality	2.5 ± 0.8	2
Sleep latency	2.2 ± 0.7	2
Sleep duration	4.0 ± 0.7	0
Sleep efficiency	1.3 ± 0.9	1
Sleep disturbance	2.4–0.6	2
Use of sleeping Medications	0.4 ± 0.8	0
Daytime dysfunction	2.1 ± 0.8	2
Total PSQI	11.3 ± 3.2	11

Note: PSQI, Pittsburgh sleep quality index; SD, standard deviation.

Table 1. Sleep quality components among patients in the study sample (n = 125).

Sleep quality (PSQI) score	Frequency	%
Good (<5)	4	3.2
Poor (≥5)	121	96.8

Note: PSQI, Pittsburgh sleep quality index.

Table 2. Sleep quality score among patients in the study sample (n = 125).

Items	Unstandardized coefficients		Standardized coefficients	*t*-test	*P*-value	95% CI for B	
	B	Std. Error				Lower	Upper
Constant	-0.34	1.96		-0.173	0.863	-4.22	3.54
Female gender	3.21	0.80	0.43	4.009	<0.001	1.62	4.79
Income	10.91	0.53	0.29	3.613	<0.001	0.86	2.95
Duration of DM	0.11	0.06	0.15	1.856	0.066	-0.01	0.23
Oral + insulin	0.83	0.46	0.15	1.815	0.072	-0.08	1.73
Smoking	2.14	1.03	0.22	2.079	0.040	0.10	4.18
Dyslipidemia	0.98	0.53	0.15	1.859	0.066	-0.06	2.03

Note: *r*-square = 0.27; Model ANOVA: $F = 7.36$, $P < 0.001$; Variables entered and excluded: age, education, job, marital status, residence, family history.
ANOVA, analysis of variance; CI, confidence interval; DM, diabetes mellitus; PSQI, Pittsburgh sleep quality index.

Table 3. Best fitting multiple linear regression model for PSQI score.

HbA1c level. The regression model explains a 0.10% variation in change of this level as indicated by the *r*-square value.

Table 6 illustrates that the PSQI score was a statistically significant independent positive predictor of control of DM. And controlled hypertension was an independent positive predictor. The regression model explains a 0.372% variation in DM control as indicated by the *r*-square value.

Table 7 illustrates the statistically significant relation between glycemic control and sleep efficiency, sleep disturbance, subjective sleep quality, and daytime dysfunction factors (P = 0.046, P = 0.02, P = 0.03, P = 0.001) respectively. It is noticed that patients who had insufficient sleep, sleep disturbance, bad sleep, and daytime dysfunction suffer from poor glycemic control compared to good glycemic control.

Glycated Hb (HbA1c)	Frequency	%
<7.0	12	9.6
≥7.0	113	90.4

Note: Range: 6.9–8.0; Mean ± SD: 7.7 ± 0.5; Median: 8.
HbA1c, glycated hemoglobin A1c; SD, standard deviation.

Table 4. glycemic control level among patients in the study sample (n = 125).

Table 8 reveals that a statistically significant relation was found between HbA1c and sleep quality (P = 0.003), It is noticed patients with poor sleep quality had poor glycemic control compared to patients with good sleep quality.

4. Discussion

The incidence of sleep disturbance is common among people with type 2 diabetes.[13] Sleep disturbance could be one of the determinants that impair glycemic control.[14]

Concerning characteristics of the study sample, the results showed that the mean age of diabetic patients was 49.6 ± 8.4, and more than two-thirds of them had a positive family history, especially in Tamil Nadu in India. Geetha et al.[15] found that the mean age of the participants was 56.08 ± 10.04 and nearly 68.8% of T2DM patients had a family history of the disease. On the other hand, the majority of diabetic patients were obese and overweight, similar to what was reported from Saudi Arabia by AlShahrani,[16] obesity and overweight prevalence in type II diabetes patients was 85.8%; additionally, about two-thirds of patients were on oral treatment. Similarly, in Mansoura District, Egypt Azzam et al.[17] found that 60% of the subjects were taking oral hypoglycemic agents.

Items	Unstandardized coefficients		Standardized coefficients	*t*-test	*P*-value	95% CI for B	
	B	Std. Error				Lower	Upper
Constant	7.67	0.68		11.218	0.000	6.32	9.03
Income	0.74	0.38	0.17	1.944	0.054	–0.01	1.50
Duration of DM	0.08	0.04	0.16	1.786	0.077	–0.01	0.16
Smoking	1.10	0.57	0.17	1.930	0.056	–0.03	2.23
Female gender	–1.31	0.45	–0.26	–2.924	0.004	–2.20	–0.42
PSQI score	0.16	0.06	0.24	2.678	0.008	0.04	0.28

Note: r-square = 0.10; Model ANOVA: F = 3.38, P = 0.020; Variables entered and excluded: age, gender, education, job, marital status, residence, treatment type, family history.
ANOVA, analysis of variance; CI, confidence interval; DM, diabetes mellitus; HbA1c, glycated hemoglobin A1c; PSQI, Pittsburgh sleep quality index.

Table 5. Best fitting multiple linear regression model for the HbA1c level.

Items	Wald	Df	*P*-value	OR	95.0% CI for OR	
					Upper	Lower
Constant	2.366	1	0.124	13.246		
Controlled Hypertension	4.898	1	0.027	9.081	1.287	64.071
PSQI score	8.876	1	0.003	0.592	0.420	0.836

Note: Nagelkerke R square: 0.372; Hosmer and Lemeshow Test: P = 0.991; Omnibus Tests of Model Coefficients: $P < 0.001$.
DM, diabetes mellitus; CI, confidence level; PSQI, Pittsburgh sleep quality index.

Table 6. Best fitting multiple logistic regression model for the control of DM.

PSQI	Diabetes (HbA1c)				Mann–Whitney test	*P*-value
	good glycemic control (<7)		Poor glycemic control (≥7)			
	Mean ± SD	Median	Mean ± SD	Median		
Sleep efficiency	0.8 ± 1.0	0.50	1.4 ± 0.9	1.00	3.99	0.046*
Sleep duration	0.2 ± 0.4	0.00	0.4 ± 0.8	0.00	1.38	0.24
Sleep disturbance	2.0 ± 0.7	2.00	2.5 ± 0.6	3.00	5.03	0.02*
Sleep latency	1.8 ± 0.8	2.00	2.2 ± 0.7	2.00	2.47	0.12
Subjective sleep quality	2.0 ± 0.4	2.00	2.5 ± 0.8	2.00	4.68	0.03*
Use of sleeping medications	0.3 ± 0.9	0.00	0.4 ± 0.8	0.00	1.20	0.27
Daytime dysfunction	1.4 ± 0.7	1.00	2.2 ± 0.7	2.00	11.16	0.001*
Total PSQI	8.5 ± 3.0	8.50	11.6 ± 3.1	12.00	8.47	0.004*

Note: HbA1c, glycated hemoglobin A1c; PSQI, Pittsburgh sleep quality index; SD, standard deviation.

Table 7. Relations between PSQI scores of the good glycemic and poor glycemic control patients.

Sleep quality (PSQI)	Diabetes control (HbA1c)				χ^2 test	*P*-value
	Good glycemic control		Poor glycemic control			
	No.	%	No.	%		
Good (<5)	3	75.0	1	25.0		
Poor (≥5)	9	7.4	112	92.6	Fisher	0.003*

Note: HbA1c, glycated hemoglobin A1c; PSQI, Pittsburgh sleep quality index.

Table 8. Relation between glycemic control and sleep quality.

Concerning sleep quality components, the study results revealed that sleep duration, subjective sleep quality, and sleep disturbance were the highest mean score. That is to say, the higher the mean score, the poorer the quality of sleep. As in Japan, where Sakamoto et al.[18] found that sleep duration, subjective sleep quality, and sleep latency had the highest mean score among diabetic patients.

About sleep quality score among diabetic patients, the results showed that most of the diabetic patients had poor sleep quality ≥5. Faulty lifestyle might play an important role in sleep quality such as sleep insufficiency, sleep latency, and short sleep duration. There is confirmation showing that a lack of 3 h of sleep leads to increases in sleep quality score by 5.[13] In Jordan, this result is similar to Barakat et al.'s finding[4] which showed that the majority of T2DM patients (81.0%) suffer from poor sleep quality.

Concerning factors affecting PSQI score including female gender was a statistically significant independent positive predictor of PSQI score. This might be due to sleep disorders such as restless legs syndrome (RLS), obstructive sleep apnea (OSA), and insomnia which are more common in women during distinct hormonal and physical changes at specific time points of women's life span such as menopause, puberty, and pregnancy can influence sleep health and lead to gender-specific clinical disorders.[19]

In India, such finding was in agreement with Babu et al.[20] who reported that females suffered poor sleep quality when compared to males and this relation was statistically significant.

Also, income was a statistically significant independent positive predictor of the PSQI score. This is perhaps due to differences in personality traits and thinking in life matters. Conversely, a study done by Wu et al.[21] in China found that lower income was associated with an increased risk of poor sleep quality, and this might be due to cultural differences.

The duration of DM was an independent positive predictor of the PSQI score. This might be due to the longer duration of diabetes connected with complications. Moreover, diabetes patients with poor glycemic control will develop nocturia, resulting in frequent awakenings, which leads to poor sleep quality[22] In Ethiopia, this resulted in the same context as Jemere et al.[22] clarified that longer duration of diabetes since diagnosis was a factor significantly associated with poor sleep quality.

Also oral and insulin treatments were independent positive predictors of PSQI score. This might be due to

nocturnal hypoglycemia leading to sleep disruption and is considered one of the many factors that cause poor sleep quality among diabetics. Longer intervals between self-monitoring glycemia are generally seen during the night and this period is associated with the highest sensitivity to treatment of diabetes[23] In Jordan, in the same context, Barakata et al.[4] found that poor sleep quality was significantly associated with insulin use while in Sinamangal Khakurel and Shakya[24] diabetic patients receiving oral hypoglycemic agents were more likely to have poor sleep quality versus patients receiving insulin only. On the contrary, Rajendran et al.[25] did not establish significant relation between sleep quality and the type of treatment of diabetes.

Smoking was an independent positive predictor of PSQI score. This was due to the effect of nicotine consumption in the brain, as nicotine is a mild stimulant to the central nervous system This association might be explained by the effect of snoring resulting from a reduction in breathing (hypopnea) and decrease in oxygen saturation because of smoking.[4] This finding was in the same context as Liao et al.[26] who carried out a study in China, and found that smokers who were diabetic patients had statistically significant and had poor sleep quality and sleep disturbances compared to non-smokers.

Finally, dyslipidemia was an independent positive predictor of the PSQI score. This might be due to statin therapy which is the most common drug for lowering cholesterol levels associated with an increased risk of sleep disturbances including insomnia. In other studies, statin therapy might cause hallucinations and nightmares. Few clinical trials are on evaluating the effect of statins on sleep as a primary outcome. Three of them suggested an essential effect of statins on sleep quality[27] In the same line, in China, Zhan et al.[28] found that a higher prevalence of dyslipidemia was associated with frequent insomnia compared to those who had no insomnia. A recent study suggested that short sleep duration was associated with higher risks of hypercholesterolemia in adults. Furthermore, according to Mahmood et al.[29] subjects with poor sleep quality had higher total cholesterol and triglycerides compared to those with good sleep quality.

Regarding HbA1c level, the study results showed that most of the diabetic patients had poor glycemic control ≥7. This can be explained that patients with DM have less experience regarding risk factors associated with poor glycemic control including poor diet habits and sedentary lifestyle, poor sleep, treatment, and follow-up.[30] In Taif Alsaeudia, a similar result was proved by Obaid et al.[14] who found that according to HbA1c, the majority of patients were having uncontrolled DM (83.3%).

Concerning factors affecting the HbA1c level, the study results revealed that income was a statistically significant independent positive predictor of HbA1c level. On the contrary Rutte et al.'s[31] systematic reviews and meta-analyses showed that there was an inverse association between socioeconomic status and HbA1c levels in people with type 2 diabetes. People of low socioeconomic status have higher HbA1c levels than people of high socioeconomic status. This discrepancy might be because most of the study participants were residing in rural areas and had low income characterized by good sleep habits that help in glycemic control than those who had high income.

The duration of DM was an independent positive predictor of HbA1c level. This is explained by a study done by Khattab et al.[32] who reported that a longer duration of diabetes was associated with insulin metabolism disturbance and poor glycemic control. In the same context, In India, Mammoo and Girija[33] realized that the duration of diabetes is one of the reasons for poor glycemic control; there is a statistically significant association between the duration of diabetes for >5 years and uncontrolled DM.

Also, smoking was an independent positive predictor of HbA1c level, and the explanation of this finding is perhaps that smoking is one cause of type 2 diabetes. The more cigarettes a person smokes, the higher the risk for type 2 diabetes forms. In fact, people with diabetes who smoke are more likely than those who don't smoke to have trouble with insulin dosing and managing their condition resulting in poor glycemic control (U.S. Department of Health and Human Services, 2014).[34] This result was in the same line with Choi et al.[35] who carried out research in Korea and found that persons who smoke cigarettes had significantly higher HbA1c levels than non-smokers. Additionally, in Japan, Hu et al.[36] found that smoking was correlated with poor glycemic control.

While the female gender was a statistically significant independent negative predictor of HbA1c level. From the researcher's point of view, psychological factors and treatment responses of females play an important role in lowering HbA1c. This result was consistent with that of Yuan et al.[37] in Taiwan, China who reported that there was no significant change in HbA1c in males, but there was a 0.10% reduction in females. On the contrary, in Brazil Duarte et al.[38] found that HbA1c levels in women were higher than in men and this difference was statistically significant.

Regarding factors that control DM, the results showed that controlled hypertension was an independent positive predictor of control of DM and the explanation might be due to high blood pressure leading to Insulin resistance syndrome.[39] So the more control of

blood pressure, the lower insulin resistance that leads to control of diabetes. In Ethiopia, in the same line, Muleta et al.[40] found that uncontrolled blood glucose was an independent predictor of uncontrolled blood pressure. Bad glycemic control was more likely to have hypertension. Therefore, more effort ought to be devoted to controlling the blood pressure in diabetics.

And results showed PSQI score was a statistically significant independent positive predictor of control of DM. From the researcher's point of view the good sleep quality, the more control of diabetes. Similarly, Zaraspe et al.[41] *in the Philippines* glucose control is directly associated with sleep quality score. Patients with bad glucose control were more likely to have bad sleep quality.

Concerning the relation between sleep quality and glycemic control, the research results displayed that there was a statistically significant relation between glycemic control and subjective sleep quality, sleep efficiency, sleep disturbance, and daytime dysfunction *components.* It is noticed that patients who had bad sleep, sleep inefficiency, and the presence of sleep disturbance and daytime dysfunction suffered from poor glycemic control compared to good glycemic control. This reflected that the importance of improving sleep quality components will lead to control of HbA1C and inversely. These findings were supported by a study done by Tsai et al.[42] in Taiwan which showed that there was a significant association between sleep efficiency and HbA1c these findings propose that low sleep efficiency is strongly associated with poorer glycemic control and in China, Zhu et al.[13] found that risk factors for poor glycemic control were sleep disturbance and daytime dysfunction. The risk for poor glycemic control would increase when one increases the score of sleep disturbance and daytime dysfunction. Additionally, In Amsterdam, Brouwer et al.[43] found that subjective sleep quality was significantly associated with higher HbA1c in individuals with lower efficiency and worse quality.

Also, the current results revealed that a statistically significant relation was established between HbA1c and sleep quality, and it is noticed that patients with poor sleep quality have poor glycemic control compared to patients with good sleep quality. The rationale of this phenomenon might be due to 2 possible causes to explain this relation. First, the cerebral cortex, cerebral limbic system, and hypothalamus, which induce the secretion of catecholamines from the sympathetic ganglion and adrenal medulla and of cortisol from thepituitary–adrenal system is stimulated by sleep deprivation. These hormones may function to raise the plasma glucose level.[42] Second, activation of the sympathetic nervous system promotes insulin resistance due to elevation of the levels of cortisol and IL-6 resulting from poor sleep quality.[33] The previous finding was supported by several studies carried out by Khakurel and Shakya[24] in Sinamangal. There was a significant relation between sleep quality with glycemic control. Mammoo and Girija[33] in Sri Manakula showed a positive correlation between PSQI score and HbA1c. In Iraq Al-Humairi and Hassan[30] found a highly statistically significant relationship between the level of HbA1c and sleep quality. There was also a significant increase in the level of HbA1c among patients with type 2 diabetics with poor sleep quality.

5. Conclusions

The study results bring about the conclusion that poor sleep quality and poor glycemic control were very common among type 2 diabetic patients. There was a highly statistically significant relation between sleep quality and glycemic control.

Strength and Limitation

Strengths of this study

- Measurement of hemoglobin A1C was performed using a reliable method in a central laboratory. Avoiding problems with lack of standardization reported by other authors
- Policymakers including health care personnel and hospital administrators should focus on providing regular screening for sleep quality and providing a program of sleep health education and counseling at diabetic clinics for patients with sleep disorders.

Limitations of this study

- This study used cross-sectional design, which has its limitations, because the temporal relationship between the exposure and the outcome can't be determined with certainty
- The sample size of this study was small because data were collected only starting from the beginning of January 2021 to the end of May 2021during the COVID pandemic, so the flow rate of patients was very little
- only used self-reported PSQI for assessment of sleep quality rather than objective measures such as polysomnogram
- Additionally, although the results in this study indicated that sleep quality can affect glycemic control in patients with type 2 diabetes, no further interventions were given to those who suffered from sleep disorders.

Recommendations

According to the present study findings, the subsequent recommendations are suggested:

1. Nursing intervention ought to be conducted for diabetic patients where they should be taught about the importance of sleep, sleep physiology, sleep disturbances, and their negative impact on general health as well as well-being.
2. Periodic assessment of sleep quality for patients is to be performed which may help develop an appropriate intervention to enhance sleep and control diabetes.
3. Further research are recommended as involving large samples, for generalization.

Ethical approval

This study was approved by the ethics committee of the faculty of nursing and this committee consists of 3 members: Prof.Dr. Amina Saad, Prof.Dr. Amany Sobhy, and Prof.Dr. Nadia Mohamed.

Conflicts of interest

There are no conflicts of interest.

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