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Research Article

Impact of Sleep Quality on Glycaemic Control in Type 2 Diabetes: A Cross-sectional Study

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ABSTRACT

Background: Inadequate sleep is associated with type 2 diabetes (T2DM) and has a negative impact on glycaemic management. The purpose of this research was to examine the relationship between sleep quality and glucose control in individuals with T2DM. **Methods:** A cross-sectional study was conducted at the Family Medicine Clinic of University of Ilorin Teaching Hospital (UITH), a tertiary hospital in North-Central Nigeria. Three hundred and seventy-eight participants took part in the research (103 men and 275 women). Questionnaires were used to compile the data, and the Pittsburgh Sleep Quality Index was included. Diabetic indicators were gathered using a combination of a thorough medical history assessment and a battery of diagnostic testing. Statistical analysis was conducted using the SPSS software version 20.0. **Results:** The median age of the respondents was 61.01 (S.D. ± 9.8) years. Seventy-four percent (74%) of people reported having poor sleep quality, 45.5% had poorly controlled diabetes, and 29.9% were obese. Inadequate sleep or poor sleep quality was shown to be statistically linked with poor glycaemic management (p= 0.0001). There were significant associations between glycaemic management and subjective sleep quality (OR 1.495, 95% C.I 1.039-2.152), sleep disturbances (OR 0.279, 95% C.I 0.122-0.636), and daytime dysfunction (OR 3.571, 95% C.I 2.253-5.662). **Conclusion:** This research shows that poor glycaemic management is linked to poor sleep quality in people with T2DM.

Keywords:
Type 2 diabetes mellitus, Sleep quality, daytime dysfunction, glycated haemoglobin, sleep disturbance

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1. Introduction

Type 2 diabetes (T2DM) is on the rise across the world. According to the International Diabetes Federation (IDF) Diabetes Atlas (2021), T2DM affects 537 million people throughout the globe. It is projected that by the year 2030, this figure would have increased to 643 million. Across Africa, 24 million people aged 20-70 years were diabetic in 2021. A possible 33 million will be living with T2DM by 2030, with 55 million by 2045 (IDF, 2021). The IDF has identified T2DM as one of the most rapidly expanding health concerns of the 21st century. Mortality and disability rates have risen as a result of the devastating effects. Damage to the kidneys, blood vessels, and nerves, as well as 1.6 million fatalities worldwide each year, are all directly attributable to T2DM (Zhang *et al.*, 2019; Nasir *et al.*, 2022).

There is a correlation between sleep deprivation and T2DM. Loss of sleep disrupts the body's endocrine, sympathovagal, and metabolic balance (Briançon-Marjollet *et al.*, 2015; Parameswaran and Ray, 2022). Diabetics often have trouble sleeping because, low-quality sleep is a common complication of T2DM due to sleep problems coupled to physiological imbalances (Surani *et al.*, 2015; Khandelwal *et al.*, 2017). Daytime exhaustion and somnolence may be caused by complications of T2DM such as painful diabetic polyneuropathy, nocturia, restless legs syndrome (RLS), and sleep-related pulmonary disturbances. According to a meta-analysis, persons with T2DM who have poor sleep quality had a higher glycated haemoglobin (HbA1c). Both short and long sleep durations negatively affect HbA1c levels, demonstrating a U-shaped dose-response relationship between sleep time and HbA1c(Lee, Ng and Chin, 2017; Zhu, Quinn and Fritschi, 2018).

A possible mechanism through which sleep disturbances significantly contribute to the onset and progression of diabetes is via the neuro-endocrine metabolic system(Van Cauter *et al.*, 2008; Briançon-Marjollet *et al.*, 2015). Reduced insulin responsiveness and increased blood glucose contribute to the worsening of diabetes in people with sleep disorders, whether the problem is with sleep quality or sleep quantity(Zhu *et al.*, 2014). However, the hypothalamic-pituitary-adrenal axis may be stimulated into producing more glucocorticoid when there is a sleep disturbance. This disrupts glycaemic regulation because glucose synthesis rises while intake falls (Van Cauter, Balbo and Leproult, 2010; Herman *et al.*, 2016). In light of this, it is clear that high-quality sleep is essential for the health and well-being of diabetic patients.

Good sleep is not just about clocking in enough hours; it is also about waking up feeling refreshed and ready to take on the day illustrating the importance of quality sleep (Chasens and Luyster, 2016). Actigraph, polysomnograph, and sleep electroencephalogram are objective methods of assessing sleep quality (Svetnik *et al.*, 2020). Validated questionnaires addressing latency and efficiency may be used to assess sleep quality from a subjective perspective. It is well known that the Pittsburgh Sleep Quality Index (PSQI) is a useful instrument for measuring the quality of one's sleep (Farah, Yee and Rasdi, 2019). It is important to stress the need of sleep for good health. There is a shortage of information in Nigeria on the correlation between poor sleep and T2DM. Thus, this descriptive cross-sectional study was conducted to examine the prevalence, risk factors, and outcomes of poor sleep quality in T2DM patients attending Family Medicine Clinic of the University of Ilorin Teaching Hospital (UITH), Ilorin, Nigeria.

2. Materials and Methods

2.1. Study Participants

From August to October 2017, a descriptive cross-sectional research was undertaken in the Family Medicine Clinic (FMC) of University of Ilorin Teaching Hospital (UITH). Patients with T2DM who had been regular clinic attendees for at least 3 months were eligible to participate. All participants in this research project were required to be above the age of 18. Participants with other types of DM not T2DM, sleep disorders, severe mental or neurologic disorders, acute diabetic crises, or who were too uncomfortable to take part in the research were excluded.

The UITH Ethical Review Committee (NHREC/02/05/2010) and the National Postgraduate Medical College of Nigeria (Appendix 2) both gave their approvals before the research could commence. Patients with T2DM were recruited using a random sampling strategy; the initial sample size was determined to be 340 using a formula by Araoye (2003); however, after accounting for 10% non-response, the final sample size was 378. Each participant signed a consent form before taking part in the research.

2.2. Data Collection

The study was conducted by the researcher with the help of an assistant. During the course of the study, the researcher taught and supervised the assistant (a DFM resident) to do several tasks, including evaluation of the degree of inter-observer error.

The data collection was done in three parts:

a. Sociodemographic data collection
b. Anthropometry data collection
c. Sampling of blood for HbA1c analysis.

Structured and semi-structured questionnaires were used to obtain the Pittsburgh Sleep Quality Index (PSQI) and sociodemographic data from the patients.

2.2.1. Structured Questionnaire: Pittsburgh Sleep Quality Index (PSQI)

The PSQI was a subjective tool for measuring the quality of one's sleep. The PSQI is a 19-item questionnaire with subcategories for sleep duration, sleep efficiency, sleep disturbances, subjective sleep quality, sleep latency, daytime dysfunction, and medication use, all rated on a 4-point scale. Overall, a lower score indicates better sleep, with a score of 0-21 representing a wide range of sleep quality. Quality of sleep (less than 5) is good, whereas quality of sleep (more than 5) is negative (greater than or equal to 5) (Adewole, 2017). The survey was translated and back-translated by language experts who were not involved in the original research. Those who identified as Yoruba utilised the Yoruba translation version of the questionnaire.

2.2.2. Semi-structured Questionnaire: Sociodemographic Data

This data set contains demographics such as age, gender, education level, marital status, occupation, ethnicity, and income. The section inquired as to the smoker's and drinker's habits. Class I was the highest, and class V was the lowest, of the five categories used to categorise respondents' socioeconomic status. The respondents' indices of socioeconomic status were based on their professions and levels of education. Class 1 included upper-level government personnel, professionals, managers, and businessmen. Officials and high school educators make up Class 2, while class 3 comprises middle school educators, cab drivers, and tradespeople. Class 4 includes people like peddlers, labourers, and messengers. Class 5 consisted of the underprivileged, including the unemployed, full-time housewives, students, and small-scale farmers.

For the educational attainment, class 1 was awarded to University graduates, class 2 to school certificate holders, class 3 to grade II teacher certificate holders or its equivalent, class 4 to primary 6 certificate holders, while illiterates or those who could barely read or write were in class 5.

2.2.3. Anthropometry and Biochemical Parameters

Using conventional equipment (weighing scale (Hanson H6IW mechanical bathroom scale with magnified display white, Amazon, United Kingdom) and stadiometer (Secca 217 Mechanical Stadiometer, Medisave, United Kingdom)) and in accordance with WHO recommendations, we assessed the participants' body mass index (BMI), using weight and height measurement. Patients' BMI was calculated by using their weight as a fraction of their squared height (m^2). Obesity was defined as a BMI of 30 or more, with underweight defined as a BMI <18.4kg/m^2, normal defined as a BMI of 18.5-24.9kg/m^2, overweight defined as a

BMI of 25-29.9kg/m^2, and obesity defined as a BMI of >30kg/m^2. Respondents were classified as either obesity class 1 (BMI 30-34.9kg/m^2), class II (35-39.9kg/m^2), class III (>40kg/m^2), or non-obesity (BMI <30kg/m^2) obese (CDC, 2022).

The selection of HbA1c cut-off numbers was based on the established guidelines provided by the WHO/IDF, which recommend a threshold of 7%. To determine HbA1c levels, a standard procedure was followed, involving the collection of blood samples from the patients. The collected blood samples were then treated with a haemolysis reagent to facilitate the lysis of red blood cells. Subsequently, an automated equipment (QUO lab$^{(R)}$ HbA1c analyzer, EKF Diagnostics, UK), was used to incubate and read the samples.

In accordance with the WHO/IDF recommendation, a HbA1c cut-off value of 7% was adopted. Good glycaemic control was defined as a HbA1c of less than 7%, whereas poor glycaemic control was defined as a HbA1c of 7% or more (Cheneke *et al.*, 2016).

2.3. Statistical Analyses

Continuous data such as age, weight, height, and body mass index were summarised using means and standard deviations (Mean ± SD). Percentages were used to summarise categorical factors such as gender, education level, marital status, and the presence or absence of diabetes complications and co-morbidities. Results were presented as percentages for an overall sleep quality score, with excellent and bad sleep quality being classed separately. The variables were analysed using a Chi-square test. Predictors of poor sleep quality were identified using logistic regression analysis. The threshold of statistical significance for all tests was set at 5% (95% confidence interval). SPSS, a statistical programme for the social sciences, version 20.0 was used for the studies' statistical analysis.

3. Results

3.1. Medical and Socio-demographic Variables of the Participants

Three hundred and seventy-eight type 2 diabetes patients from the FMC, UITH in Ilorin were included in the research. A breakdown of the respondents' demographics, socioeconomic, and medical data is provided in Table 1 and 2. Overall, there were 275 (72.8%) women and 103 (27.2%) men, for a female-to-male ratio of 2.7:1. With a standard deviation of 9.8 years, the mean age of responders was 61.01 years. Of all responses, those aged 60–69 made up the largest single demographic, with 148 or 39.2 percent.

Eighty-two percent of those who participated in the survey had married partners; 15.3 percent had lost a spouse; 3.4% were never married. Two-third (68.5%) 259 of those who responded identified as Muslims and one-third 31.5%) 119 as Christians. In total, 345 (91.3% of the total) of the respondents identified as Yoruba. About 3.6 percent of those surveyed identified as Igbo. The remaining 1.6% belonged to the Baruba, 1.1% to the Hausa/Fulani, 1.1% to the Nupe, 0.8% to the Edo, and 0.5% to the Ebira. Nearly half of the 188 respondents (49.7%) were monogamous. Only around a quarter of the respondents (27.2%) had completed post-secondary education above the bachelor's level, while almost a third (31.2%) had none at all. Forty-one percent of the sample was comprised of traders. Class V respondents made up the largest part (41.3%), while class III respondents accounted for the smallest (5%). Three of every ten survey respondents belonged to socioeconomic class II. Fourteen percent of respondents were classified as having the lowest socioeconomic status (Class IV), while just 8.2 percent were in the highest socioeconomic class (Class I). One-third of respondents (31.2% of the total) had monthly incomes of \$14.98 or less, while another third (36.5% of the total) earned between \$14.98 and \$29.96. In fact, just 8.2 percent of workers made more than \$149.8. There were 151 people in the sample who were overweight, 101 who were at a normal weight, and 21.7%, 6.6%, and 1.6% were classified as class I, II, and III obese participants. The mean (SD) BMI for the sample was 27.5 (5.05).

There were 113 morbidly obese individuals (29.9%), compared to 265 (70.1%) who were not overweight. 45.5% of the sample had a HbA1c (≥ 7) indicate poorly managed DM. Most of the participants 266 (70.4%), while having a mean global PSQI score of 6.16±2.7, experienced inadequate sleep.

3.2. Correlation between Sociomedical Factors and Global Sleep Quality (PSQI)

The correlation between sociomedical conditions and good sleep is seen in Table 3 and Table 4. As can be seen in the Table 3, PSQI scores tend to decrease as age increases. Poor sleep quality was most prevalent among those aged 70 and over (78.6%), and least prevalent among those below 39 years (50%). The association between increasing age and poor sleep quality was statistically significant at p=0.033. Among the different types of families, single parents had the worst sleep quality (100%) while monogamous couples had the best (64.4%). The association between sleep quality and family type is statistically significant at p=0.017. There was no statistically significant difference in sleep quality by gender, ethnicity, religion, or marital status. Furthermore, the lowest rate of poor sleep was found among college graduates (55.3%), while the greatest rate was found among individuals with no formal education (79.7%). This shows that education is significantly (p=0.001) correlated with sleep quality. In term of occupation, poor sleep quality was indicated by 100% of farmers but less among the housewives (33.3%) at p=0.0001. Statistical analysis, however, found no correlation between income and sleep quality as p=0.071. as shown in Table 4, there was no statistical difference (p=0.451) between BMI and sleep quality of the respondents, although the highest percentage of poor sleepers (84.6%) were classified as underweight. Similar to the BMI, there was no statistical significance (p=0.175) between obesity status and sleep quality despite 65% of the obese population reported poor sleep quality, 72.5% of the non-obese population did so as well. Among those who reported excellent glycaemic control, 118 (57.4%) had bad sleep quality, whereas among those who reported poor glycaemic control, 148 (86%) had poor sleep quality. This indicates that the likelihood of a poor sleep result is increased (statistically significant at p=0.0001) in those with poor glycaemic control compared to those with excellent glycaemic control.

3.3 Logistic Regression Analysis of Sleep Quality, glycaemic control, and Respondents' Variables

Poor glycaemic control was predicted by many factors, as shown in Table 3. These included poor subjective sleep quality (OR 1.495, 95% C.I 1.039-2.152), sleep disruptions (OR 0.279, 95% C.I 0.122-0.636), and daytime dysfunction (OR 3.571, 95% C.I 2.253-5.662). Table 4 summarizes the findings of a confounding factor analysis, which revealed that HbA1c was the strongest predictor of overall sleep quality (OR 4.87, 95% C.I. 4.866-2.847).

4. Discussion

4.1. Sociodemographic, Medical Factors and Sleep Quality

In this study, poor sleep quality in T2DM patients is substantially correlated with age, family composition, educational attainment, and employment status (Table 1). Participants in the study had a mean age of 61.01 (± 9.8) years. Here, we found that advancing age was associated with poor sleep quality, but not substantially. There is a correlation between age and sleep quality, with those over 60 being more likely to have poor sleep than those between the ages of 30 and 59. The quality of sleep declines with age due to changes in sleep architecture as well as due to bad physical conditions (Gadie *et al.*, 2017; Li, Vitiello and Gooneratne, 2018).More women than men took part in our study (72.8% vs. 27.2%), however this had no effect on participants' ability to get a good sleep. This finding is supported by data from a Japanese control group study (Narisawa *et al.*, 2017).

Table 1. Socio-demographic of the Participants

Variable	Good Sleep (n = 112)		Bad Sleep (n = 266)		P-value
	No.	Percent (%)	No.	Percent (%)	
Age (years)					0.033*
≤ 39	2	50.0	2	50.0	
40-49	8	24.2	25	75.8	
50-59	44	40.4	65	59.6	
60-69	40	27.0	108	73.0	
≥ 70	18	21.4	66	78.6	
Gender					0.701
Male	29	28.2	74	71.8	
Female	83	30.2	192	69.8	
Ethnicity					0.292
Yoruba	106	30.7	239	69.3	
Igbo	4	28.6	10	71.4	
[a]Others	2	10.5	17	89.5	
Religion					0.875
Christianity	36	30.3	83	69.7	
Islam	76	29.3	183	70.7	
Marital status					0.176
Married	92	30.4	211	69.6	
Separated or divorced	3	23.1	10	76.9	
Widowed	15	25.9	43	74.1	
Single (never married)	0	0.0	2	100.0	
Family type					0.017*
Monogamous	67	35.6	121	64.4	
Polygamous	45	24.5	139	75.5	
Single parent	0	0.0	6	100.0	
Highest level of education attained					0.001*
Tertiary	46	44.7	57	55.3	
Secondary	14	28.6	35	71.4	
Primary	13	22.8	44	77.2	
Quranic	9	24.3	28	75.7	
Vocational	6	42.9	8	57.1	
No formal education	24	20.3	94	79.7	
Main occupation (in the last 12 months)					0.0001*
Unemployed	9	16.7	45	83.3	
Housewife	6	66.7	3	33.3	
Trader	43	27.6	113	72.4	
Artisan	12	28.6	30	71.4	
Farmer	0	0.0	4	100.0	
Civil servant	31	52.5	28	47.5	
Retired	11	22.4	38	77.6	
Others	0	0.0	5	100.0	
Income ($)					0.071
< 14.98	31	26.3	87	73.7	
14.98-29.96	21	23.1	70	76.9	
29.96 – 149.8	52	37.7	86	62.3	
> 149.8	8	25.8	23	74.2	

N=Total number of respondents is 378 *=significant below P < 0.01

[a] = Other ethnic groups found in Kwara included Baruba, Ebira, Hausa, Fulani, Edo and Nupe.

Table 2. Medical Characteristics of the Participants

Variable	**Good Sleep (n = 112)**		**Bad Sleep (n = 266)**		**P-value**
	No.	**Percent (%)**	**No.**	**Percent (%)**	
BMI					0.451
Underweight	2	15.4	11	84.6	
Normal weight	31	30.7	70	69.3	
Overweight	40	26.5	111	73.5	
Obese class I	26	31.7	56	68.3	
Obese class II	11	44.0	14	56.0	
Obese class III	2	33.3	4	66.7	
Obese status					0.175
Non-obese	73	27.5	192	72.5	
Obese	39	34.5	74	65.5	
HbA1c status					0.0001*
Good control (< 7%)	88	42.7	118	57.3	
Poor control (≥ 7%)	24	14.0	148	86.0	

*=significant below P < 0.01

Table 3. Relationship between Social factors and Global Sleep Quality Index (PSQI)

Variables	**χ^2Value**	**Df**	**p value**
Age	10.473	4	**0.033**
≤ 39 years			
40-49 years			
50-59 years			
60-69years			
≥ 70 years			
Gender	0.148	1	0.701
Male			
Female			
Ethnicity	7.318	2	0.292
Yoruba			
Igbo			
Others			
Religion	0.032	1	0.857
Christianity			
Islam			
Marital Status	6.333	3	0.176
Married			
Separated or divorced			
Widowed			
Single (never married)			
Family Type	8.143	2	**0.017**
Monogamous			
Polygamous			
Single parent			
Highest level of education attained	23.071	6	0.001*
Tertiary			
Secondary			
Primary			
Quranic			
Vocational			
No formal education			
Main Occupation (in the last 12 months)	30.472	7	0.0001*
Unemployed			
Housewife			
Trader			
Artisan			
Farmer			
Civil servant			
Retired			
Others			
Income ($)	7.020	3	0.071
< 14.98			
14.98-29.96			
29.96 – 149.8			
> 149.8			

χ^2= Chi square test, df = degree of freedom, p = significance, *$p < 0.05$

Table 4. Relationship between Medical factors and Global Sleep Quality Index (PSQI)

Variables	χ^2Value	Df	p value
BMI	4.719	5	0.451
Underweight			
Normal weight			0.175
Overweight			0.0001*
Obese class I			
Obese class II			
Obese class III			
Obese status	1.844	1	
Non-obese			
Obese			
HbA1c status	1.844	1	
Good control (< 7%)			
Poor control (≥ 7%)			

χ^2= Chi square test, df = degree of freedom, p = significance, *p < 0.05

Table 5. Logistic regression analysis of the PSQI score with respondents' variables

Respondents' variables	Global PSQI				
	β value	**S.E.**	**p value**	**OR**	**95% C.I.**
Age categories	0.136	0.148	0.356	1.146	0.858 - 1.531
Sex	-0.217	0.318	0.494	0.805	0.431 - 1.501
Religion	-0.455	0.302	0.132	0.635	0.351 - 1.147
Marital status	-0.022	0.158	0.889	0.978	0.718 - 1.333
Family type	0.496	0.257	0.053	1.642	0.993 - 2.716
Highest level of education	0.175	0.067	0.009*	1.191	1.045 - 1.357
Income status	0.085	0.296	0.774	1.089	0.609 - 1.946
Duration of diabetes	0.103	0.148	0.489	1.108	0.828 - 1.482
Hb1Ac status	1.582	0.273	0.000*	4.866	4.866 - 2.847
Obesity	-0.226	0.275	0.412	0.798	0.465 - 1.368

β value = coefficient of regression, S.E. = standard error, OR = odds' ratio, **p <0.05*

Some studies reported that women have more poor sleep quality than men (Gupta and Wang, 2016; Barakat *et al.*, 2019; Zhu *et al.*, 2019) while it was shown in another study that male sex was related to worse quality of sleep (Modarresnia *et al.*, 2018).

According to our findings, unemployment is a major contributor to poor sleep. Similar study have shown that persons who are unemployed had worse sleep quality than those who are actively employed (Barakat *et al.*, 2019). Stress, poor self-esteem, and despair are just some of the mental health issues that may result from being unemployed. Consequences of this may include inadequate time spent sleeping and poor sleep quality (Hiswåls *et al.*, 2017).This study also found an association between educational level and sleep quality. Those with lower levels of education were shown to be at greater risk of experiencing poor sleep than those with higher levels of education supported by a recent study conducted in South Korea (Kim *et al.*, 2017). Cutler and Lleras-Muney, (2006) discovered that education had an effect on the health of populations. Money, access to healthcare, problem-solving skills, social networks, and social status are all potential determinants. Based on their analysis, Mendoza-Meléndez *et al.*, (2016) found that being single (i.e., not married) is a strong predictor of poor sleep (OR 3.6, $p < 0.005$). We found no significant difference in sleep quality based on marital status, which is consistent with other research (Bani-issa, Al-Shujairi and Patrick, 2018; Barakat *et al.*, 2019).

In our study, we used a BMI of ≥25 kg/$m^2$to indicate overweight. The majority of the participants (69.8%) were overweight or obese, however they did not suffer from sleep problems. In a similar study, Yoshikawa *et al.* (2022) reported a relationship between PSQI and BMI, a report that contradicted Shamshirgaran *et al.* (2017) who reported no relationship between the two even at a BMI above 25 kg/m^2. Sokwalla *et al.*, (2017) also found that those with a higher BMI had worse quality sleep. The two studies that found a positive relationship between BMI and PSQI both pointed to the notion that obstructive sleep apnoea, common in T2DM patients, causes sleep fragmentation owing to intermittent hypoxia, which would then decrease sleep quality.

4.2. Prevalence of Poor Sleep Quality

According to the results of this research, 70.4% of T2DM patients seen at the UITH's FMC suffer from poor sleep quality as measured by the PSQI. This reveals that disturbed sleep is more common in T2DM patients than in patients (32.5% to 68.7%) visiting regular outpatient clinics in parts of Nigeria (James, Omoaregba and Igberase, 2011; Nuhu *et al.*, 2013; Ford *et al.*, 2014). The results of this study are consistent with studies done on identical T2DM population in India, Iran, and Jordan, which indicated that 69%, 70% and 81% of those surveyed experienced poor sleep quality (Rajendran *et al.*, 2012; Barakat *et al.*, 2019; Mehrdad *et al.*, 2021). There have also been reports of decreased sleep quality in other studies. Zhu et al. (2014) performed research in China on 220 individuals with T2DM and found that 47.1% of them were poor sleepers (Zhu *et al.*, 2014). The sleep quality of T2DM patients was similarly low (55.6% overall) as reported by Jemere *et al.* (2019) in Ethiopia. There is a possibility that the PSQI cut-off of ≥8 used to classify poor sleepers reduces the opportunity to detect more sleep problems, which might account for the lower value found by Zhu and colleagues. Sleep deprivation or poor-quality sleep has been linked to a variety of negative health consequences, including but not limited to: increased systemic inflammatory markers; high blood pressure; reduced glucose tolerance; and the development of T2DM. This association sheds light on why so many people with T2DM also have trouble sleeping.

Reduced levels of pancreatic γ-aminobutyric acid (GABA) have been linked to poor sleep and insomnia (Park *et al.*, 2020). Similarly, GABA has been shown to possess anti-diabetic activity by acting on the immune cells and pancreatic beta cells to reduce inflammation and aid insulin secretion

(Al-Kuraishy *et al.*, 2021). Poor sleep is impacted by its low levels in people with diabetes. Involved in glucose metabolism, orexins have their expression reduced by obesity, sleep apnoea, and depression (Surani *et al.*, 2015; von Deneen and Garstka, 2022). Poor glycaemic management is linked to polyuria and nocturia, both of which disrupt sleep quality, and affected over half of the index study's respondents. People over the age of 60 made up the majority of respondents, and sleep problems are more common as people become older (Cybulski *et al.*, 2019; Dangol, Shrestha and Rai Koirala, 2020). Most of the people who answered the call had just a high school diploma or less, which may have affected their ability to relax at night.

4.3. Factors Associated with Poor Quality of Sleep and Glycaemic Control

The results of a logistic regression analysis in this study demonstrate that poor glycaemic management is predictably linked to poor subjective sleep quality, sleep disruptions, and daytime dysfunction. This is consistent with the results of Zhu and colleagues, who, after controlling for gender, age, and duration of T2DM, found that sleep latency, sleep disruptions, and daytime dysfunction were predictors of poor glycaemic management (Zhu *et al.*, 2014). According to these results, improving patients' quality of sleep may help them better manage their blood glucose levels. Improved subjective sleep quality, reduced occurrence of sleep disruptions, and less impairment throughout the daytime are all important goals for people with T2DM.Our results indicated that poorly managed diabetes (HbA1c >7%) has a deleterious effect on sleep quality. The vast majority of subjects in our study (86.0%) had a HbA1c level >7%, which may explain the association. Tsai *et al.* (2012) found a positive association between sleep quality and HbA1c (r = 0.54, p<0.01. These results suggest that improved glucose control follows from improved sleep quality. Cappuccio *et al.* (2010) identified a correlation between better diabetes management and better sleep quality using the PSQI. Lack of quality sleep was linked with poor glucose control in those with diabetes. This association may be explained by the fact that patients with poorly managed diabetes are more prone to have severe diabetic neuropathy and osmotic diabetic symptoms, both of which may interrupt sleep by prompting frequent bathroom visits (Zelman, Brandenburg and Gore, 2006; Kim *et al.*, 2014).

This study has several limitations such as the data being collected at a single point in time, potentially limiting the direct influence of the variables studied on the observed associations. Long-term studies are needed to confirm the associations and caution is advised in interpreting the results regarding poor glycaemic control. Additionally, since the study was conducted in a hospital setting, the generalizability of the results to other settings may be limited. Further research should address these limitations.

Based on the research findings, several recommendations are proposed to improve sleep among patients with T2DM receiving primary care. These include raising awareness among primary care providers about sleep issues in people with T2DM and providing education on addressing them. Postgraduate medical schools should offer lectures and updates on sleep medicine. Regular screening for sleep problems in outpatient clinics can facilitate early intervention. Patient education on good sleep hygiene is crucial for achieving optimal rest and preventing complications like poor glycaemic control. Sleep medicine centres should be an integral part of academic medical centres to enhance expertise in identifying and treating sleep disorders effectively. Lastly, encouraging and funding research in sleep medicine can further expand knowledge in the field through schol5arly journals.

5. Conclusion

Our study showed that 45.5% of patients with T2DM had poor glycaemic control, which is also associated with poor sleep quality. This suggests that a large proportion of persons with T2DM have inadequately managed their condition. Poor sleep quality is significantly associated to factors including subjective sleep quality, sleep interruptions, daytime dysfunction, highest level of education, and Hb1Ac status. Patients with T2DM should have a thorough management plan, especially at the primary care level. Thus, greater effort is needed to aid those with T2DM in getting a better night's rest via efforts such as encouraging sleep hygiene and giving sleep education.

Authors' Contributions

Ayinla GA - conceptualization, proposal writing, ethical review presentation, literature review, study design, study procedure, data collection, data analysis, result collection, manuscript writing, final authorization.

Ayinmode/Kuranga - literature review, study design, discussion writing, final authorization

Ayinla MT/Yaaqub - literature review, study design, discussion writing, manuscript writing, final authorization

Okesina - study design, data collection, data analysis, discussion writing, final authorization

References

Adewole, O. (2017) Pattern of Sleep Disorders among Patients in a Nigerian Family Practice Population. *Annals of Medical and Health Sciences Research* [Preprint]. Available at: https://www.amhsr.org/articles/pattern-of-sleep-disorders-among-patients-in-a-nigerian-family-practice-population-3815.html (Accessed: 13 September 2022).

Al-Kuraishy, H., Hussian, N., Al-Naimi, M., Al-Gareeb, A., Al-Mamorri, F. and Al-Buhadily, A. (2021) The potential role of pancreatic γ-aminobutyric acid (GABA) in diabetes mellitus: A critical reappraisal. *International Journal of Preventive Medicine*, **12**(*1*). doi:10.4103/ijpvm.IJPVM_278_19.

Araoye, M. (2003) *Research methodology with statistics for health and social sciences. Ilorin: Nathadex Publisher; Nathadex*. Ilorin: Nathadex Publishers. Available at: http://www.malariajournal.com/content/11/S1/O15Bani-issa, W., Al-Shujairi, A.M. and Patrick, L. (2018) Association between quality of sleep and health-related quality of life in persons with diabetes mellitus type 2. *Journal of Clinical Nursing*, **27**(*7–8*), pp. 1653–1661. doi:10.1111/JOCN.14221.

Barakat, S., Abujbara, M., Banimustafa, R., Batieha, A. and Ajlouni, K. (2019) Sleep Quality in Patients With Type 2 Diabetes Mellitus. *Journal of Clinical Medicine Research*, **11**(*4*), pp. 261–266. doi:10.14740/JOCMR2947W.

Briançon-Marjollet, A., Weiszenstein, M., Henri, M., Thomas, A., Godin-Ribuot, D. and Polak, J. (2015) The impact of sleep disorders on glucose metabolism: Endocrine and molecular mechanisms. *Diabetology and Metabolic Syndrome*, **7**(*1*). doi:10.1186/S13098-015-0018-3.

Cappuccio, F.P., D'Elia, L., Strazzullo, P. and Miller, M.A. (2010) Quantity and quality of sleep and incidence of type 2 diabetes: A systematic review and meta-analysis. *Diabetes Care*, **33**(*2*), pp. 414–420. doi:10.2337/DC09-1124.

Van Cauter, E., Balbo, M. and Leproult, R. (2010) Impact of sleep and its disturbances on hypothalamo-pituitary-adrenal axis activity. *International Journal of Endocrinology*, **2010**. doi:10.1155/2010/759234.

Van Cauter, E., Spiegel, K., Tasali, E. and Leproult, R. (2008) Metabolic consequences of sleep and sleep loss. *Sleep Medicine*, **9**(*SUPPL. 1*). doi:10.1016/S1389-9457(08)70013-3.

CDC (2022) *Defining Adult Overweight & Obesity | Overweight & Obesity | CDC*. Available at: https://www.cdc.gov/obesity/basics/adult-defining.html (Accessed: 10 October 2022).

Chasens, E.R. and Luyster, F.S. (2016) Effect of sleep disturbances on quality of life, diabetes self-care behavior, and patient-reported outcomes. *Diabetes Spectrum*, **29**(*1*), pp. 20–23. doi:10.2337/DIASPECT.29.1.20.

Cheneke, W., Suleman, S., Yemane, T. and Abebe, G. (2016) Assessment of glycemic control using glycated hemoglobin among diabetic patients in Jimma University specialized hospital, Ethiopia. *BMC research notes*, **9**(*1*). doi:10.1186/S13104-016-1921-X.

Cutler, D.M. and Lleras-Muney, A. (2006) Education and health: evaluating theories and evidence. Available at: https://www.nber.org/papers/w12352 (Accessed: 1 October 2022).

Cybulski, M., Cybulski, L., Krajewska-Kulak, E., Orzechowska, M., Cwalina, U. and Kowalczuk, K. (2019) Sleep disorders among educationally active elderly people in Bialystok, Poland: A cross-sectional study. *BMC Geriatrics*, **19**(*1*), pp. 1–8. doi:10.1186/S12877-019-1248-2/TABLES/10.

Dangol, M., Shrestha, S. and Rai Koirala, S.K. (2020) Insomnia and its associated factors among older people of selected ward of Banepa municipality, Nepal. *Nursing Open*, **7**(*1*), p. 355. doi:10.1002/NOP2.396.

von Deneen, K.M. and Garstka, M.A. (2022) Neuroimaging perspective in targeted treatment for type 2 diabetes melitus and sleep disorders. *Intelligent Medicine* [Preprint]. doi:10.1016/J.IMED.2022.05.003.

Farah, N.M.F., Yee, T.S. and Rasdi, H.F.M. (2019) Self-reported sleep quality using the malay version of the pittsburgh sleep quality index (PSQI-M) in Malaysian adults. *International Journal of Environmental Research and Public Health*, **16**(*23*). doi:10.3390/IJERPH16234750.

Ford, E.S., Li, C., Wheaton, A.G., Chapman, D.P., Perry, G.S. and Croft, J.B. (2014) Sleep duration and body mass index and waist circumference among U.S. adults. *Obesity (Silver Spring, Md.)*, **22**(*2*), pp. 598–607. doi:10.1002/OBY.20558.

Gadie, A., Shafto, M., Leng, Y., Kievit, R.A. and Cam-CAN (2017) How are age-related differences in sleep quality associated with health outcomes? An epidemiological investigation in a UK cohort of 2406 adults. *BMJ Open*, **7**(*7*). doi:10.1136/BMJOPEN-2016-014920.

Gupta, S. and Wang, Z. (2016) Predictors of sleep disorders among patients with type 2 diabetes mellitus. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, **10**(*4*), pp. 213–220. doi:10.1016/J.DSX.2016.06.009.

Herman, J.P., McKlveen, J.M., Ghosal, S., Kopp, B., Wulsin, A., Makinson, R., Scheimann, J. and Myers, B. (2016) Regulation of the hypothalamic-pituitary-adrenocortical stress response. *Comprehensive Physiology*, **6**(*2*), p. 603. doi:10.1002/CPHY.C150015.

Hiswåls, A.S., Marttila, A., Mälstam, E. and Macassa, G. (2017) Experiences of unemployment and well-being after job loss during economic recession: Results of a qualitative study in east central Sweden. *Journal of Public Health Research*, **6**(*3*), pp. 135–141. doi:10.4081/JPHR.2017.995.

IDF (2021) *Diabetes Facts & figures*. Available at: https://www.idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html (Accessed: 5 June 2022).

James, B., Omoaregba, J. and Igberase, O. (2011) Prevalence and correlates of poor sleep quality among medical students at a Nigerian university. *Annals of Nigerian Medicine*, **5**(*1*), p. 1. doi:10.4103/0331-3131.84218.

Jemere, T., Mossie, A., Berhanu, H. and Yeshaw, Y. (2019) Poor sleep quality and its predictors among type 2 diabetes mellitus patients attending Jimma University Medical Center, Jimma, Ethiopia. *BMC Research Notes*, **12**(*1*). doi:10.1186/S13104-019-4531-6.

Khandelwal, D., Dutta, D., Chittawar, S. and Kalra, S. (2017) Sleep Disorders in Type 2 Diabetes. *Indian Journal of Endocrinology and Metabolism*, **21**(*5*), p. 758. doi:10.4103/IJEM.IJEM_156_17.

Kim, S.S., Won, J.C., Kwon, H.S., Kim, C.H., Lee, J.H., Park, T.S., Ko, K.S. and Cha, B.Y. (2014)

Prevalence and clinical implications of painful diabetic peripheral neuropathy in type 2 diabetes: Results from a nationwide hospital-based study of diabetic neuropathy in Korea. *Diabetes Research and Clinical Practice*, **103**(*3*), pp. 522–529. doi:10.1016/J.DIABRES.2013.12.003.

Kim, W.J., Joo, W.T., Baek, J., Sohn, S.Y., Namkoong, K., Youm, Y., Kim, H.C., Park, Y.R., Chu, S.H. and Lee, E. (2017) Factors Associated with Insomnia among the Elderly in a Korean Rural Community. *Psychiatry investigation*, **14**(*4*), pp. 400–406. doi:10.4306/PI.2017.14.4.400.

Lee, S.W.H., Ng, K.Y. and Chin, W.K. (2017) The impact of sleep amount and sleep quality on glycemic control in type 2 diabetes: A systematic review and meta-analysis. *Sleep Medicine Reviews*, **31**, pp. 91–101. doi:10.1016/J.SMRV.2016.02.001.

Li, J., Vitiello, M. V. and Gooneratne, N.S. (2018) Sleep in Normal Aging. *Sleep medicine clinics*, **13**(*1*), p. 1. doi:10.1016/J.JSMC.2017.09.001.

Mehrdad, M., Azarian, M., Sharafkhaneh, A., Alavi, A., Zare, R., Rad, A.H. and Dalili, S. (2021) Association Between Poor Sleep Quality and Glycemic Control in Adult Patients with Diabetes Referred to Endocrinology Clinic of Guilan: A Cross-sectional Study. *International Journal of Endocrinology and Metabolism*, **20**(*1*). doi:10.5812/IJEM.118077.

Mendoza-Meléndez, M., Jimenez-Correa, U., Gallegos-Cari, A., Ayala-Guerrero, F. and Jiménez-Anguiano, A. (2016) Prevalence of sleep disorders, daytime sleepiness and clinical symptomatology in older adults. *Revista Médica del Hospital General de México*, **79**(*3*), pp. 136–143. doi:10.1016/J.HGMX.2016.05.021.

Modarresnia, L., Golgiri, F., Madani, N.H., Emami, Z. and Tanha, K. (2018) Restless Legs Syndrome in Iranian People With Type 2 Diabetes Mellitus: The Role in Quality of Life and Quality of Sleep. *Journal of Clinical Sleep Medicine*, **14**(*2*), pp. 223–228. doi:10.5664/JCSM.6938.

Narisawa, H., Komada, Y., Miwa, T., Shikuma, J., Sakurai, M., Odawara, M. and Inoue, Y. (2017) Prevalence, symptomatic features, and factors associated with sleep disturbance/insomnia in Japanese patients with type-2 diabetes. *Neuropsychiatric Disease and Treatment*, **13**, pp. 1873–1880. doi:10.2147/NDT.S134814.

Nasir, N.F.M., Draman, N., Zulkifli, M.M., Muhamad, R. and Draman, S. (2022) Sleep Quality among Patients with Type 2 Diabetes: A Cross-Sectional Study in the East Coast Region of Peninsular Malaysia. *International Journal of Environmental Research and Public Health 2022, Vol. 19, Page 5211*, **19**(*9*), p. 5211. doi:10.3390/IJERPH19095211.

Nuhu, F., Yusuf, A., Adeyemi, S. and Kalu, A. (2013) Sleep quality among primary care attendees in Kaduna, Northern Nigeria: a case-control study. *International journal of psychiatry in medicine*, **46**(*3*), pp. 291–301. doi:10.2190/PM.46.3.D.

Parameswaran, G. and Ray, D.W. (2022) Sleep, circadian rhythms, and type 2 diabetes mellitus. *Clinical Endocrinology*, **96**(*1*), pp. 12–20. doi:10.1111/CEN.14607.

Park, S., Kang, I., Edden, R.A.E., Namgung, E., Kim, Jinsol and Kim, Jungyoon (2020) Shorter sleep duration is associated with lower GABA levels in the anterior cingulate cortex. *Sleep medicine*, **71**, p. 1. doi:10.1016/J.SLEEP.2020.02.018.

Rajendran, A., Parthsarathy, S., Tamilselvan, B., Seshadri, K.G. and Shuaib, M. (2012) Prevalence and correlates of disordered sleep in Southeast Asian Indians with type 2 diabetes. *Diabetes and Metabolism Journal*, **36**(*1*), pp. 70–76. doi:10.4093/DMJ.2012.36.1.70.

Sokwalla, S.M.R., Joshi, M.D., Amayo, E.O., Acharya, K., Mecha, J.O. and Mutai, K.K. (2017) Quality of sleep and risk for obstructive sleep apnoea in ambulant individuals with type 2 diabetes mellitus at a tertiary referral hospital in Kenya: a cross-sectional, comparative study. *BMC endocrine disorders*, **17**(*1*).

doi:10.1186/S12902-017-0158-6.

Surani, S., Brito, V., Surani, A. and Ghamande, S. (2015) Effect of diabetes mellitus on sleep quality. *World Journal of Diabetes*, **6**(*6*), p. 868. doi:10.4239/WJD.V6.I6.868.

Svetnik, V., Snyder, E.S., Tao, P., Roth, T., Lines, C. and Herring, W.J. (2020) How well can a large number of polysomnography sleep measures predict subjective sleep quality in insomnia patients? *Sleep Medicine*, **67**, pp. 137–146. doi:10.1016/J.SLEEP.2019.08.020.

Tsai, Y.W., Kann, N.H., Tung, T.H., Chao, Y.J., Lin, C.J., Chang, K.C., Chang, S.S. and Chen, J.Y. (2012) Impact of subjective sleep quality on glycemic control in type 2 diabetes mellitus. *Family Practice*, **29**(*1*), pp. 30–35. doi:10.1093/FAMPRA/CMR041.

Zelman, D.C., Brandenburg, N.A. and Gore, M. (2006) Sleep impairment in patients with painful diabetic peripheral neuropathy. *Clinical Journal of Pain*, **22**(*8*), pp. 681–685. doi:10.1097/01.AJP.0000210910.49923.09.

Zhang, Y., Lin, Y., Zhang, J., Li, L., Liu, X., Wang, T. and Gao, Z. (2019) Association between insomnia and type 2 diabetes mellitus in Han Chinese individuals in Shandong Province, China. *Sleep and Breathing*, **23**(*1*), pp. 349–354. doi:10.1007/S11325-018-1687-6.

Zhu, B., Martyn-Nemeth, P., Ruggiero, L., Park, C.G., Zhang, Y. and Fritschi, C. (2019) Associations between fatigue, sleep disturbance and eating style in adults with type 2 diabetes: A correlational study. *Journal of Clinical Nursing*, **28**(*17–18*), pp. 3200–3209. doi:10.1111/JOCN.14883.

Zhu, B., Quinn, L. and Fritschi, C. (2018) Relationship and variation of diabetes related symptoms, sleep disturbance and sleep-related impairment in adults with type 2 diabetes. *Journal of Advanced Nursing*, **74**(*3*), pp. 689–697. doi:10.1111/JAN.13482.

Zhu, B.Q., Li, X.M., Wang, D. and Yu, X.F. (2014) Sleep quality and its impact on glycaemic control in patients with type 2 diabetes mellitus. *International Journal of Nursing Sciences*, **1**(*3*), pp. 260–265. doi:10.1016/J.IJNSS.2014.05.020.