Jurnal
Berita Ilmu Keperawatan

Jurnal Berita Ilmu Keperawatan
Vol. 16 (2) Tahun 2023
p-ISSN: 1979-2697
e-ISSN: 2721-1797

Sleep and HbA1c in Adult Patients with Type 2 Diabetes Mellitus

Rizki Andriani[1]*, Orita Satria[2], Nurhadia[3], Crasdian Afri Yudi[4]

[1,2]*STIKes Medika Seuramoe Barat Meulaboh, 23616, Provinsi Aceh, Indonesia*
[3,4]*Rumah Sakit Umum dr. Zainoel Abidin Banda Aceh, 24415, Provinsi Aceh, Indonesia*
*Correspondence : rizkiandriani.qq@gmail.com

Abstract: *Sleep is one of the essential factors in life and affects glucose metabolism, so it is crucial for diabetic patients to have good quality sleep to control their diabetes. The study aimed to analyze the relationship between sleep quality and HbA1c levels in adult patients with type 2 diabetes mellitus. This study was conducted with a cross-sectional study approach with a sample of 170 respondents with convenience sampling from a hospital in Banda Aceh. Sleep quality data was measured by the Pittsburgh Sleep Quality Index (PSQI), and HbA1c levels were obtained from the results of respondents' HbA1c examinations in the last three months analyzed through chi-square. The results showed a significant relationship between sleep quality and respondents' HbA1c levels (p = 0.008), where respondents (64.1%) with poor sleep quality had an eight times the risk of having uncontrolled HbA1c levels compared to respondents with good sleep quality. Education on the importance of sleep health in patients regularly should be carried out in groups by health services to motivate T2DM patients to enjoy adequate sleep and improve their glycemic control through learning media that interest patients*

Keywords: *Hemoglobin A1c; Quality of Sleep; Type 2 Diabetes Mellitus*

INTRODUCTION

Globally, diabetes mellitus (DM) is a significant public health problem of great concern and a cause of death in most countries. International Diabetes Federation (2021) states that currently, there are 537 million people living with diabetes, where Indonesia is the country with the fifth position as the most countries with 19.5 million people living with diabetes. Diabetes Mellitus (DM) is a clinical disorder syndrome characterized by the presence of hyperglycemia metabolic disease caused by defects in insulin secretion, defects in insulin action or both (Setyaningsih & Maliya, 2018).

Improper lifestyle can result in an increase in blood sugar levels (Mujabi & Yuniartika, 2018). Thus, lifestyle identification is critical to modify related factors that can decrease the occurrence of clinical symptoms in diabetic patients. Sleep is a new and significant risk factor to modify to achieve better glycemic control in Type 2 Diabetes Mellitus (T2DM) patients (Lee et al., 2017). Ohkuma et al. (2014) mentioned that 39% of people with T2DM experienced sleep disturbances, and 55% of T2DM patients experienced poor sleep quality (Luyster & Dunbar-Jacob, 2011). These results also follow a systematic review study conducted by Khalil et al. (2020) on 41 research articles showing that the prevalence of sleep disorders in diabetic patients is estimated to be around 52%.

High blood sugar levels in T2DM patient cause typical signs and symptoms in the form of increased appetite, excessive thirst, frequent urge to urinate, especially at night, weight loss, and fatigue. Poor management will cause the development of these symptoms into complications and will affect the occurrence of clinical symptoms in diabetic patients(Grossman & Porth, 2014). This is in line with Surani (2015) who states that in T2DM patients, there are conditions that can affect the quality and quantity of sleep, including nocturia, polyuria, nocturnal hypoglycemia, diabetic neuropathy, obstructive sleep apnea, restless leg syndrome, cardiovascular complications, hypertension, stroke, and depression.

In addition to the four main pillars of Diabetes Mellitus control consisting of education, medical nutrition therapy, physical activity, and pharmacological interventions (Soelistijo et al., 2019), additional interventions are also needed in the form of maintaining good sleep quality to be able to

control blood sugar levels in diabetics (Bellon et al., 2021). Sleep disorders in diabetics will reduce sleep quality. Sleep quality can be seen from the duration of sleep, the time needed to be able to sleep, the number of times awakened, and the depth of sleep (Khalil et al., 2020). Poor sleep quality is closely related to poor levels of glycemic control, so improved sleep quality in diabetic patients can lead to better glycemic control and improved quality of life (Tsai et al., 2012). Sleep quality is associated with decreased insulin sensitivity, increased fasting plasma glucose levels, and increased HbA1c. Optimal sleep quality and decreased HbA1c in people with T2DM may be associated with a 3% reduction in mortality, a 2% reduction in the incidence of myocardial infarction, and a 5% reduction in microvascular complications (Lee et al., 2017; Zhu et al., 2014). A systematic review study and meta-analysis of randomized controlled trials conducted by Sondrup et al. (2022) on 35 articles showed that sleep duration, quality, and timing are very important for metabolism and reducing the risk of T2DM.

Glycemic control in patients can be evaluated by looking at HbA1c levels because it reflects blood sugar levels in the last three months. If the HbA1c value is≥ 6.5%, the patient is diagnosed with diabetes (Soelistijo et al., 2019). Several studies analyzed the impact of sleep quality on glycemic control in T2DM patients. A systematic literature review study and meta-analysis of 26 observational articles covering a population of T2DM patients in Asia showed that good sleep quality significantly lowered fasting blood sugar levels compared to poor sleep quality (M: 11.28; CI 95%) (Azharuddin et al., 2020). Likewise, the results of the systematic review study of Azizah et al. (2022) on 13 research articles covering 25,193 samples of T2DM patients showed that respondents with poor sleep quality had higher HbA1c so that there was a relationship between sleep quality and glycemic control (HbA1c).

Decreased sleep quality can impair the patient's ability to think, cause physical fatigue, the ability to respond quickly, and decrease work productivity. This will affect the patient's ability to manage DM management independently related to the metabolic status, which aims to maintain blood glucose levels within normal limits and prevent hypoglycemia and hyperglycemia (Smyth et al., 2020). Research studies on sleep quality and glycemic control in patients with Diabetes Mellitus have been widely conducted in Indonesia and abroad, stating whether sleep quality and glycemic control are a relationship. However, so far, these studies have mainly used samples or research respondents of people with diabetes who are in the range of adults to old age, and no one has focused on DT2DM patients who are in adulthood only, namely more than 18 years and less than 60 years. Researchers consider this necessary because old age will naturally cause sleep disorders. It is feared that it will create confusion in the research results whether sleep disorders come from diabetes experienced or due to natural changes in age.

The results of a simple mini-survey conducted by researchers at Endocrine outpatient unit found that seven out of ten adult patients with T2DM interviewed had sleep pattern disorders where sleep is not sound and often restless during sleep, besides that patients said they were often surprised at night, so they woke up from sleep and could not fall back asleep. Two out of ten patients say they often wake up at night due to the urge to urinate, which is often felt so that it disturbs the patient's sleep. Health workers, doctors, and nurses at the endocrine outpatient unit said education related to disturbed sleep patterns for patients and how to overcome them had been carried out but not done regularly.

Based on the description above, sleep quality must be investigated further so that health workers can do the things needed to maintain optimal glycemic control. This study analyzes the relationship between sleep quality and HbA1c levels in Adult Patients with Type 2 Diabetes Mellitus.

METHOD

This study is the study that uses a cross-sectional approach. Researchers involved 170 respondents, namely T2DM patients aged 18-60 years, who had laboratory data on HbA1c levels in the last three months who visited the endocrine outpatient unit at General Hospital dr. Zainoel Abidin hospital in Banda Aceh, willing to participate in research, able to communicate and

understand Indonesian instructions fluently. Respondents were selected using convenience sampling techniques.

The instrument used in this study was Pittsburgh Sleep Quality Index (PSQI) to see sleep quality. score and sleep duration. The PSQI instrument is used to evaluate a person's sleep quality in the previous month and is widely used because it is easy and accurate. PSQI, developed by Buysse et al. (1989) at the University of Pittsburgh, America, has a sensitivity of 89.6% and specificity of 86.5% so that it can be used to identify sleep disorders (Buysse et al., 2008). The PSQI instrument can measure sleep quality in 1-month intervals consisting of 19 questions that measure seven assessment components: subjective sleep quality, sleep latency, sleep duration, sleep disturbance, sleep efficiency, use of sleeping pills, and sleep dysfunction during the day. The assessment of the results of the questionnaire answers has a range of 0-3, then added up from each component until a total number of 0-21 is obtained. There are several cut-off points from PSQI used, namely >5 to ≥8, but more studies use a cut point >5 (Azizah et al., 2022). Therefore the study will use the interpretation of sleep quality data both if the score is ≤ 5 and bad if the score is> 5.

The PSQI questionnaire has been translated and back-translated by commercial translation agencies to maintain the content used. This questionnaire 's validity and reliability test was conducted on 30 respondents who visited the endocrine outpatient at General Hospital dr. Zainoel Abidin outside of the research respondents. The results of the questionnaire 's validity that was carried out by researchers on each component of the questionnaire obtained two invalid questions ($r < 0.361$) from 19 questions with a reliability value of 0.702. Considering that the invalid question item is an integral part of the instrument to assess sleep quality, the researcher does not discard the question item and only changes the redaction of the sentence so that it does not change the assessment score system that is already valid.

In addition, the respondent's sleep duration will also be calculated, which includes the length of one's sleep at night only or the length of one's sleep in one day, where napping is also considered. Analysis of a systematic review of seven articles conducted by Azharuddin et al. (2020) states that the standard average sleep duration is 7-8 hours per day, and the short sleep duration is characterized by < 6 hours. This study will interpret good sleep quality data if the sleep duration is 7-8 hours.

Glycemic control in this study was collected by looking at the results of HbA1C measurements from patients' medical records within the last 1-3 months. HbA1c levels correspond to blood sugar levels in type 2 DM patients. The results of the HbA1C examination are expressed in 2 categories, namely controlled (<6.5%) and uncontrolled (≥ 6.5%) (Soelistijo et al., 2019). Data analysis in this study used chi-square.

RESULT

Table 1. Demographic Characteristics of Respondents (n=170)

Characteristic	Frequency (n)	Percentage (%)
Age (years)		
18-45	56	32.9
46-60	114	67.1
Sex		
Male	57	33.5
Female	113	66.5
Education		
Primary School	38	22.3
Middle & High School	78	45.9
Bachelor	54	31.8
Employment		
Employed	114	67.1
Unemployed	56	32,9
Duration Of Diabetes		
< 3 year	112	65.9
> 3 year	58	34.1
Total	170	100

Table 1 shows the characteristics of respondents in this study consisting of 66.5% (113) female respondents, where 67.1% (114) respondents were in the age group of 46-60. 67.1% (114) of respondents are employed, with the majority of 45.9% (78) respondents having a recent secondary education (junior high school and high school). Based on the length of suffering from T2DM, it was seen that 65.9% (112) respondents had diabetes for less than three years

Table 2. Descriptive Statistics of Quality of Sleep and HbA1c Level (n=170)

Item	Frequency (n)	Percentage (%)
Quality of Sleep		
Good	61	35.9
Poor	109	64.1
HbA1c levels		
Controlled	66	38.8
Uncontrolled	104	61.2
TOTAL	170	100

Table 2 shows that more than half of respondents (64.1%) experienced poor sleep quality and had HbA1c levels that were categorized as uncontrolled (≥ 6.5%), which was 61.2% of respondents.

Table 3. Sleep Disorder Complaints (n=170)

Sleep Disorder (in a month)	Never		1 time a week		2 time a week		More than 3 times a week	
	n	%	n	%	n	%	n	%
Cannot sleep within 30 minutes	20	11.7	36	21.2	26	15.3	88	51.8
Waking up in the middle of the night or too early in the morning	10	17.6	17	10.0	30	17.6	93	54.7
I had to get up to the bathroom	5	2.9	15	8.8	30	17.6	120	70.6
Unable to breathe comfortably	84	49.4	45	26.5	26	15.3	15	8.8
Cough at night	63	37.1	45	26.5	42	24.7	20	11.8
Feeling cold during sleep	129	75.9	17	10.0	14	8.2	10	5.9
Feeling hot during sleep	45	26.5	38	22.4	46	27.1	41	24.1
Nightmare	67	39.4	18	10.6	31	18.2	54	31.8
Feeling pain	12	7.1	34	20.0	46	27.1	78	45.9

Table 3 shows complaints of sleep disorders that are often experienced (more than 3x every week) by respondents in the past month, are most likely to get up to the bathroom (70.6%), wake up in the middle of the night, or too early (54.7%), cannot sleep within 30 minutes (51.8%), and feel pain (45.88%).

Table 4. Correlation Between Quality of Sleep and HbA1C Level

Quality of Sleep	HbA1c Level				OR (95% CI)	p value
	Control		Uncontrolled			
	n	%	n	%		
Good	39	22.9	27	15.9	8,052 (1.630-9.682)	0.008
Poor	28	16.5	76	44.7		

Table 4 shows the relationship between sleep quality and HbA1c levels. The results of the chi-square analysis showed that there was a significant relationship between sleep quality and HbA1c levels of respondents (p = 0.008) with OR= 8.052 (95% CI: 1.630-9.682), which means that respondents with poor sleep quality levels had an eight times greater chance of having HbA1c levels in the uncontrolled category (≥ 6.5%) compared to respondents who had good sleep quality.

DISCUSSION

Sleep Quality of Adults with Type 2 Diabetes

Sleep quality is a complex thing related to a person's sleep patterns, habits, and duration in meeting sleep needs. This study looked at sleep quality through the PSQI instrument. This study showed that 109 respondents (64.1%) experienced poor sleep quality. This result is in line with Rajendran et al.'s (2012) research on 120 T2DM patients, where 69% of respondents experienced poor sleep quality, Zahra & Farida (2020) research on 110 T2DM patients aged 35-65 years showed 60% of respondents experienced poor sleep quality, and Aini's (2016) research which stated that respondents had poor sleep quality, which was 63.2%. The respondents taken in this study were adult respondents according to the provisions of Menteri Kesehatan Republik Indonesia (2016) because they wanted to avoid sleep quality problems caused by aging age so that the results of research related to sleep

quality in respondents came from the condition of diabetes experienced and not because of age. The average PSQI score obtained is 5-9, which shows that the average respondent has poor sleep quality.

Sleep has been shown to regulate glucose tolerance and dynamic balance. Circadian regulation of sleep plays an essential role in insulin production, insulin sensitivity, and glucose consumption. Diabetes Mellitus patients who experience sleep disorders and have a short sleep duration will cause a decrease in insulin sensitivity which results in increased blood glucose and poor glycemic control that aggravates the disease (Zhu et al., 2014). The results of Gupta & Wang (2016) study of 7,239 people with diabetes and analysis of 26 literature studies (Zhu et al., 2018) estimated the prevalence of sleep problems in T2DM patients between 46% to 76%. Tan & Benedict (2020) said T2DM patients often experience sleep problems which include insufficient sleep duration, insomnia, obstructive sleep apnea (OSA), and hypersomnia. Prolonged hyperglycemia also causes changes in the body's neurobehavioral, neurotransmitters, and autonomic functions, consequently leading to sleep abnormalities (Khandelwal et al., 2017).

Poor sleep quality can be attributed to rapid changes in blood glucose levels at night and discomfort associated with peripheral neuropathy (Khandelwal et al., 2017). This study shows complaints of sleep disorders often experienced (more than 3x every week) by respondents in the past month are the most have to get up to the bathroom (70.6%). This figure surpasses the study of Chang et al. (2017)) in 275 T2DM patients, where 45.1% of patients experienced nocturia or frequent urination at night and mentioned a significant relationship between nocturia and sleep quality ($p< 0.001$). Elevated blood glucose levels cause glucose to appear in the urine (glucosuria). Glucose in urine can increase the osmolarity of tubular fluid, causing osmotic diuresis, which causes frequent urination or polyuria (Sherwood, 2012).

In addition, 54.7% of respondents in this study experienced waking up in the middle of the night or too early in the morning, and 51.8% of respondents could not sleep within 30 minutes (51.8%). This research can undoubtedly be attributed to the sleep duration of diabetic patients in this study. The average sleep duration of respondents is between 5-7 hours, so there are still respondents with a sleep duration that is less than usual. Some of the factors researchers found related to this are modern lifestyles characterized by more demanding workloads and increased use of technology before bedtime, leading to optimal sleep neglect and misalignment of sleep-wake cycles.

This study also showed that 45.8% of respondents felt the pain that disturbed their sleep. Pain is one of the conditions that reflect Restless Legs Syndrome (RLS); this is in line with what was revealed by Surani (2015) that one condition that worsens sleep quality in diabetic patients is RLS. The results of this study are slightly above the research of Khalil et al. (2020) which states that 27% of diabetic respondents experience restless leg syndrome. Hyperglycemic conditions will cause biochemical changes in nerve tissue so that they can interfere with metabolic processes and axon loss (Price &; Wilson, 2012). This causes decreased sensory and motor functions that make the appearance of nerve pain, such as numbness, stabbing, tingling, or burning sensation, which is generally in the lower extremities so that people with diabetes are awake at night. (Smeltzer &; Bare, 2012).

HbA1c Levels

The results of this study showed that the HbA1c levels of respondents in the last three months were more than half in the uncontrolled category (≥ 6.5%), which was 104 people (61.2%). This condition shows that the respondent's glycemic control status is included in the uncontrolled category (Soelistijo et al., 2019). The results of this study are not much different from the results of the study of Barakat et al. (2019) on 1,211 T2DM patients where as many as 70% of respondents had HbA1c levels in the uncontrolled category where this could happen because the study took the HbA1c cut off point at ≥ 7%.

Hemoglobin A1c (HbA1c) is a stable glucose bound to the N-terminal group in the HbA0 chain and commonly referred to as glycosylated hemoglobin, the primary subtype of hemoglobin, and is a bond between hemoglobin and glucose. The advantages of HbA1c testing include being standardized according to The Diabetes Control and Complication Trial (DCCT), having a better

overall glucose exposure index and being able to assess long-term complications, having low biological variability (<2%) from day to day for HbA1c compared to fasting glucose which has a variability of 12-15%), relatively unaffected by acute conditions such as stress, can be performed at any time, and is one type of examination that can be used to diagnose and assess glycemic control (Lim et al., 2018).

HbA1c testing is more recommended to establish a diagnosis of diabetes because, based on the National Health and Nutrition Examination Survey (NHANES), HbA1c levels can identify one-third more undiagnosed cases of diabetes than fasting blood sugar levels (American Diabetes Association Professional Practice Committee, 2022). HbA1c is a reliable indicator see blood glucose control over three months. Through this examination, the ability of type 2 DM patients to control their blood sugar and predict the possibility of complications or improvement can be known. HbA1c levels indicate better long-term blood sugar control than short-term blood sugar or urine levels in days or hours (Sack, dkk, 2011).

Sleep Quality and HbA1c Levels in Adult Patients with T2DM

The results of this study showed that there was a significant relationship between sleep quality and HbA1c levels in adult patients with T2DM (p = 0.008). The results of this study are in line with research by Barakat et al. (2019) in Jordan which shows a relationship between sleep quality and HbA1c levels (p = 0.000). Several studies in Indonesia have also shown a relationship between sleep quality and HbA1c levels. Zahra & Farida (2020) showed a significant relationship between HbA1c levels and respondents' sleep quality (p = 0.000).

The analysis of 9 articles by Azizah et al. (2022) also found a relationship between sleep quality and glycemic control, namely HbA1c, where respondents with poor sleep quality have higher average HbA1c levels than respondents with good sleep quality. In addition, Azizah et al. (2022) also analyzed eight articles that stated there was a relationship between sleep duration and U-shaped glycemic control, where respondents with sleep duration of 7 hours/day had the lowest HbA1c levels, while respondents with shorter sleep duration and more prolonged than 7 hours/day had higher HbA1c levels so it can be concluded that a decrease in sleep duration will cause an increase in HbA1c.

This study also showed that respondents with poor sleep quality were eight times more likely to have uncontrolled HbA1c levels than T2DM patients with good sleep quality. A study conducted by Chasens et al. (2013) of 107 T2DM patients showed that poor sleep quality was significantly associated with difficulties in self-care, medication, and dietary adherence leading to poorer glycemic control. Poor sleep quality, sedentary lifestyle, unhealthy eating patterns and imbalances between circadian rhythms & behaviour are suspected as underlying mechanisms for metabolic control disorders(Tan et al., 2018). Patients with sleep problems are more likely not to follow the recommended dietary rules for diabetic patients; this was shown in a study that showed respondents who did not get enough sleep consumed more carbohydrates, which would undoubtedly increase HbA1c values (Hogenkamp et al., 2013; Taheri et al., 2004).

Although the study did not show a specific link between sleep duration and HbA1C levels in diabetic patients, some studies have shown a link between these variables. Analysis conducted by (Lee et al., 2017) of 20 studies showed short and long sleep duration was significantly associated with higher HbA1c levels, thus indicating poor glycemic control compared to normal duration sleep. This result showed an increase of 0.23% in HbA1c levels in patients with a sleep duration of less than <6 hours/night and an increase of 0.13% in HbA1c levels in patients whose sleep duration was >8 hours/night. In line with this, a cross-sectional study on 13,346 T2DM patients aged 40-69 years conducted by Tan & Benedict (2020) showed a significant relationship between sleep duration and HbA1c (p<0.001).

This explanation can be related to the mechanism of insulin resistance to increased appetite and impaired glucose tolerance in healthy people (Azharuddin et al., 2020). Frequent sleep disturbances and short sleep duration disrupt energy balance through the mechanism of regulating

hunger and appetite, where low levels of leptin and high levels of ghrelin (both of these hormones play an essential role in regulating satiety and appetite). In addition, lack of sleep and waking up at night is associated with decreased resistance of leptin levels leading to dysregulation of the hypothalamic-pituitary-adrenal axis resulting in impaired insulin sensitivity and impaired glucose affecting glycemic control(Pejovic et al., 2010; Taheri et al., 2004).

American Diabetes Association (2017), for the first time, recommends assessment of sleep patterns and duration be part of a comprehensive medical evaluation of patients with diabetes. Sleep health is an important modifiable risk factor for improving glycemic control in T2DM patients, in addition to smoking and obesity (American Diabetes Association Professional Practice Committee, 2022). Prevention of sleep deprivation globally may not be possible because there are no uniform recommendations on optimizing sleep quality and duration, especially regarding glucose metabolism. However, an increased understanding of the physiological consequences of sleep deprivation, including sleep schedules, should be optimized or even shift workers' work schedules can be adjusted. Modifying the sleep environment or even systematically manipulating increased slow sleep waves can improve sleep quality, thereby improving the body's healthy function to maintain glucose homeostasis (Obayashi et al., 2013).

This study informs health services that most respondents have poor sleep quality and are associated with HbA1c levels. It can also be a source of information for nursing science that with poor sleep quality of T2DM patients, either unresolved sleep disorders or insufficient sleep duration can be one of the factors of uncontrolled blood glucose.

There are some limitations to this study. This study was a cross-sectional study that could only examine the association between sleep quality and HbA1c levels, so it could not determine the direction of the relationship between these two variables. It could be that people with diabetes had sleep disorders before getting a diagnosis of diabetes, and it also could not be determined whether sleep disturbances contributed to glycemic control or whether complications of diabetes contributed to sleep quality in people with diabetes. In addition, the quantity and quality of sleep were assessed at a single point, so it may not adequately capture the ongoing effects of sleep disturbance and glycemic control that occur over time in patients with T2DM. The same study with more samples is needed so that these findings can be generalized to the population. Further studies are needed with longitudinal designs where the measurement of sleep quality and glycemic control is carried out objectively, which is carried out over some time in order to obtain strategies or interventions to improve sleep quality and quantity.

CONCLUSION

This study showed that most respondents had HbA1c levels that needed to be better controlled, and there was a significant relationship between HbA1c levels and sleep quality in type 2 DM patients. Also, this study suggests that sleep quality and duration are new risk factors associated with poor glycemic control in T2DM patients. Regular patient education can be done in groups about the importance of sleep health, which can motivate T2DM patients to enjoy adequate sleep and improve glycemic control.

REFERENCE

American Diabetes Association. (2017). Standards of medical care in diabetes-2017. *Diabetes Care*, *40*(Suppl 1). https://doi.org/10.1111/1753-0407.12424

American Diabetes Association Professional Practice Committee. (2022). Facilitating Behavior Change and Well-being to Improve Health Outcomes: Standards of Medical Care in Diabetes—2022. *Diabetes Care*, *45 (Suppl.*(January), S60–S82. https://doi.org/10.2337/dc22-S005

Azharuddin, M., Kapur, P., Adil, M., Ghosh, P., & Sharma, M. (2020). The impact of sleep duration and sleep quality on glycaemic control in Asian population with type 2 diabetes mellitus: A systematic literature review and meta-analysis of observational studies. *Clinical Epidemiology and*

Global Health, *8*(3), 967–975. https://doi.org/10.1016/j.cegh.2020.03.006

Azizah, U. N., Wurjanto, M. A., Kusariana, N., & Susanto, H. S. (2022). *Relationship between Sleep Quality and Glycemic Control in Patients with Diabetes Mellitus: Systematic Review.* Hubungan Kualitas Tidur dengan Kontrol Glikemik pada Penderita Diabetes Melitus : Systematic Review. *Jurnal Epidemiologi Kesehatan Komunitas*, *7*(1), 411–422. https://doi.org/10.14710/jekk.v7i1.13310

Barakat, S., Abujbara, M., Banimustafa, R., Batieha, A., & Ajlouni, K. (2019). Sleep Quality in Patients With Type 2 Diabetes Mellitus. *Journal of Clinical Medicine Research*, *11*(4), 261–266. https://doi.org/10.14740/jocmr2947w

Bellon, F., Mora-Noya, V., Pastells-Peiró, R., Abad-Corpa, E., Gea-Sánchez, M., & Moreno-Casbas, T. (2021). The efficacy of nursing interventions on sleep quality in hospitalized patients: A systematic review of randomized controlled trials. *International Journal of Nursing Studies*, *115*, 103855. https://doi.org/10.1016/j.ijnurstu.2020.103855

Buysse, D. J., Hall, M. L., Strollo, P. J., Kamarck, T. W., Owens, J., Lee, L., Reis, S. E., & Matthews, K. A. (2008). Relationships between the Pittsburgh Sleep Quality Index (PSQI), Epworth Sleepiness Scale (ESS), and clinical/polysomnographic measures in a community sample. *Journal of Clinical Sleep Medicine*, *4*(6), 563–571. https://doi.org/10.5664/jcsm.27351

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28*(2), 193–213. https://doi.org/10.1016/0165-1781(89)90047-4

Chang, C. J., Pei, D., Wu, C. C., Palmer, M. H., Su, C. C., Kuo, S. F., & Liao, Y. M. (2017). Correlates of Nocturia and Relationships of Nocturia With Sleep Quality and Glycemic Control in Women With Type 2 Diabetes. *Journal of Nursing Scholarship*, *49*(4), 400–410. https://doi.org/10.1111/jnu.12302

Chasens, E. R., Korytkowski, M., Sereika, S. M., & Burke, L. E. (2013). Effect of Poor Sleep Quality and Excessive Daytime Sleepiness on Factors Associated with Diabetes Self-Management. *Diabetes Educator*, *39*(1), 74–82. https://doi.org/10.1177/0145721712467683.Effect

Grossman, S., & Porth, C. M. (2014). *Porth's Pathophysiology: Concepts of Altered Health States-9th edition.* (Ninth edit). Lippincott Williams & Wilkins.

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

Hogenkamp, P. S., Nilsson, E., Nilsson, V. C., Chapman, C. D., Vogel, H., Lundberg, L. S., Zarei, S., Cedernaes, J., Rångtell, F. H., Broman, J. E., Dickson, S. L., Brunstrom, J. M., Benedict, C., & Schiöth, H. B. (2013). Acute sleep deprivation increases portion size and affects food choice in young men. *Psychoneuroendocrinology*, *38*(9), 1668–1674. https://doi.org/10.1016/j.psyneuen.2013.01.012

International Diabetes Federation. (2021). IDF Diabetes Atlas 10th edition. In *IDF*. https://doi.org/10.1016/j.diabres.2013.10.013

Khalil, M., Power, N., Graham, E., Deschênes, S. S., & Schmitz, N. (2020). The association between sleep and diabetes outcomes – A systematic review. *Diabetes Research and Clinical Practice*, *161*, 1–12. https://doi.org/10.1016/j.diabres.2020.108035

Khandelwal, D., Dutta, D., Chittawar, S., & Kalra, S. (2017). Sleep disorders in type 2 diabetes. *Indian Journal of Endocrinology and Metabolism*, *21*(5), 758–761. https://doi.org/10.4103/ijem.IJEM_156_17

Lee, S. W. H., Ng, K. Y., & 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*, 91–101. https://doi.org/10.1016/j.smrv.2016.02.001

Lim, W. Y., Ma, S., Heng, D., Tai, E. S., Khoo, C. M., & Loh, T. P. (2018). Screening for diabetes with HbA1c: Test performance of HbA1c compared to fasting plasma glucose among Chinese, Malay and Indian community residents in Singapore. *Scientific Reports*, *8*(1), 1–9. https://doi.org/10.1038/s41598-018-29998-z

Luyster, F. S., & Dunbar-Jacob, J. (2011). Sleep quality and quality of life in adults with type 2

diabetes. *Diabetes Educator*, *37*(3), 347–355. https://doi.org/10.1177/0145721711400663

Menteri Kesehatan Republik Indonesia. (2016). *Regulation of the Minister of Health of the Republic of Indonesia Number 25 of 2016 concerning the 2016-2019 National Elderly Health Action Plan*. Peraturan Menteri Kesehatan Republik Indonesia Nomor 25 Tahun 2016 Tentang Rencana Aksi Nasional Kesehatan Lanjut Usia Tahun 2016-2019. In *http://hukor.kemkes.go.id/uploads/produk_hukum/PMK_No._25_ttg_Rencana_Aksi_Nasional_Kesehatan_Lanjut_Usia_Tahun_2016-2019_.pdf*.

Mujabi, M. F., & Yuniartika, W. (2018). *The Relationship between Blood Sugar Levels and Depression Levels and Physical Activity in Patients with Diabetes Mellitus.* Hubungan Kadar Gula Darah Dengan Tingkat Depresi Dan Aktifitas Fisik Pada Penderita Diabetes Mellitus. *Jurnal Berita Ilmu Keperawatan*, *11*(2), 73–83. https://doi.org/10.23917/bik.v11i2.10577

Obayashi, K., Saeki, K., Iwamoto, J., Okamoto, N., Tomioka, K., Nezu, S., Ikada, Y., & Kurumatani, N. (2013). Exposure to Light at Night, Nocturnal Urinary Melatonin Excretion, and Obesity/Dyslipidemia in the Elderly: A Cross-Sectional Analysis of the HEIJO-KYO Study. *Journal of Clinical Endocrinology & Metabolism*, *98*(1), 337–344. https://doi.org/10.1210/jc.2012–2874

Ohkuma, T., Fujii, H., Iwase, M., Ogata-Kaizu, S., Ide, H., Kikuchi, Y., Idewaki, Y., Jodai, T., Hirakawa, Y., Nakamura, U., & Kitazono, T. (2014). U-shaped association of sleep duration with metabolic syndrome and insulin resistance in patients with type 2 diabetes: The Fukuoka Diabetes Registry. *Metabolism: Clinical and Experimental*, *63*(4), 484–491. https://doi.org/10.1016/j.metabol.2013.12.001

Pejovic, S., Vgontzas, A. N., Basta, M., Tsaoussoglou, M., Zoumakis, E., Vgontzas, A., Bixler, E. O., & Chrousos, G. P. (2010). Leptin and Hunger Levels in Young Healthy Adults After One Night of Sleep Loss. *J Sleep Res*, *19*(4), 552–558. https://doi.org/10.1111/j.1365-2869.2010.00844.x.Leptin

Rajendran, A., Parthsarathy, S., Tamilselvan, B., Seshadri, K. G., & Shuaib, M. (2012). Prevalence and correlates of disordered sleep in southeast asian indians with type 2 diabetes. *Diabetes and Metabolism Journal*, *36*(4), 314–315. https://doi.org/10.4093/dmj.2012.36.4.314

Setyaningsih, R. S. D., & Maliya, A. (2018). *The Effect of Health Education on Diabetic Foot Care with Demonstration Methods on the Ability to Care for the Feet in Patients with Diabetes Mellitus.* Pengaruh Pendidikan Kesehatan Perawatan Kaki Diabetik dengan Metode Demonstrasi Terhadap Kemampuan Merawat Kaki Pada Pasien Diabetes Mellitus. *Jurnal Berita Ilmu Keperawatan*, *11*(2), 57–66. https://doi.org/10.23917/bik.v11i2.10581

Smyth, A., Jenkins, M., Dunham, M., Kutzer, Y., Taheri, S., & Whitehead, L. (2020). Systematic review of clinical practice guidelines to identify recommendations for sleep in type 2 diabetes mellitus management. *Diabetes Research and Clinical Practice*, *170*, 108532. https://doi.org/10.1016/j.diabres.2020.108532

Soelistijo, S. A., Lindarto, D., Decroli, E., Permana, H., Sucipto, K. W., Kusnadi, Y., Budiman, Ikhsan, R., Sasiarini, L., & Sanusi, H. (2019). Pedoman Pengelolaan Dan Pencegahan Diabetes Melitus Tipe 2 Dewasa di Indonesia. In *PB Perkumpulan Endokrinologi Indonesia (Perkeni)*.

Sondrup, N., Termannsen, A. D., Eriksen, J. N., Hjorth, M. F., Færch, K., Klingenberg, L., & Quist, J. S. (2022). Effects of sleep manipulation on markers of insulin sensitivity: A systematic review and meta-analysis of randomized controlled trials. *Sleep Medicine Reviews*, *62*, 101594. https://doi.org/10.1016/j.smrv.2022.101594

Surani, S. (2015). Effect of diabetes mellitus on sleep quality. *World Journal of Diabetes*, *6*(6), 868. https://doi.org/10.4239/wjd.v6.i6.868

Taheri, S., Lin, L., Austin, D., Young, T., & Mignot, E. (2004). Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. *PLoS Medicine*, *1*(3), 210–217. https://doi.org/10.1371/journal.pmed.0010062

Tan, X., & Benedict, C. (2020). Sleep characteristics and HbA1c in patients with type 2 diabetes on glucose-lowering medication. *BMJ Open Diabetes Research and Care*, *8*(1), 2–8. https://doi.org/10.1136/bmjdrc-2020-001702

Tan, X., van Egmond, L., Chapman, C. D., Cedernaes, J., & Benedict, C. (2018). Aiding sleep in type 2

diabetes: therapeutic considerations. *The Lancet Diabetes and Endocrinology*, *6*(1), 60–68. https://doi.org/10.1016/S2213-8587(17)30233-4

Tsai, Y. W., Kann, N. H., Tung, T. H., Chao, Y. J., Lin, C. J., Chang, K. C., Chang, S. S., & Chen, J. Y. (2012). Impact of subjective sleep quality on glycemic control in type 2 diabetes mellitus. *Family Practice*, *29*(1), 30–35. https://doi.org/10.1093/fampra/cmr041

Zahra, A. N., & Farida, M. E. (2020). Hubungan Kadar HbA1c dan Kualitas Tidur pada Pasien Diabetes Melitus Tipe 2. *Jurnal Persatuan Perawat Nasional Indonesia (JPPNI)*, *3*(3), 189. https://doi.org/10.32419/jppni.v3i3.170

Zhu, B. Q., Li, X. M., Wang, D., & 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), 260–265. https://doi.org/10.1016/j.ijnss.2014.05.020

Zhu, B. Q., Vincent, C., Kapella, M. C., Quinn, L., Collins, E. G., Ruggiero, L., Park, C., & Fritschi, C. (2018). Sleep disturbance in people with diabetes: A concept analysis. *Journal of Clinical Nursing*, *27*(1–2), 1–19. https://doi.org/10.1111/jocn.14010