Axis Journal of Scientific Innovations

Cross-Sectional Analysis of Sleep Duration, Stress Perception, and Blood Glucose Variability Among Urban Adults

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Acknowledgement	The authors sincerely thank all participants for their cooperation throughout the study.
Conflict of Interest	NONE

Submission: 16/Oct/2024
Publication: 30/Nov/2024

Abstract

Background: Urbanization has profoundly influenced human health by altering sleep behavior, increasing psychological stress, and contributing to metabolic disturbances. Poor sleep and heightened stress perception are emerging determinants of impaired glucose regulation, yet limited evidence exists on their combined effects among urban adults in South Asia.

Objective: To investigate how sleep quality and perceived stress levels correlate with fasting glucose and HbA1c patterns in adults living in metropolitan environments.

Methods: A cross-sectional study was conducted over four months among 100 urban adults residing in Lahore, Pakistan. Participants aged 25–55 years without diagnosed diabetes or metabolic disorders were included through convenience sampling. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), and perceived stress was evaluated using the Perceived Stress Scale (PSS-10). Fasting blood glucose and HbA1c were measured through standard laboratory methods. Descriptive statistics, Pearson's correlation, t-tests, ANOVA, and multiple regression analyses were applied using SPSS version 26, with significance set at $p < 0.05$.

Results: The mean age of participants was 38.6 ± 8.4 years, with 52% males and 48% females. The average sleep duration was 6.3 ± 1.4 hours, and 64% had poor sleep quality (PSQI > 5). A significant negative correlation was found between sleep duration and fasting glucose ($r = –0.34$, $p = 0.001$) as well as HbA1c ($r = –0.29$, $p = 0.004$). Perceived stress showed positive correlations with fasting glucose ($r = 0.37$, $p < 0.001$) and HbA1c ($r = 0.32$, $p = 0.002$). Regression analysis identified sleep duration ($\beta = –0.28$, $p = 0.006$) and stress ($\beta = 0.31$, $p = 0.004$) as independent predictors of fasting glucose.

Conclusion: Shorter sleep duration and higher perceived stress were significantly associated with increased fasting glucose and HbA1c levels among urban adults. These findings emphasize the importance of addressing sleep hygiene and stress management as integral components of metabolic health promotion in urban populations.

Keywords: Adults, Blood Glucose, HbA1c, Perceived Stress, Sleep Duration, Sleep Quality, Urban Health.

Submission: 16/Oct/2024
Publication: 30/Nov/2024

Introduction

Sleep plays a fundamental role in maintaining metabolic homeostasis, emotional stability, and overall physiological health. In recent decades, however, the rapid pace of urban life has led to significant disruptions in natural sleep cycles, contributing to a growing public health concern. Modern metropolitan environments, characterized by long working hours, digital exposure, and social stressors, have reshaped human lifestyles in ways that compromise both the quantity and quality of sleep (1). Numerous studies have associated short or irregular sleep duration with a range of adverse outcomes, including obesity, hypertension, insulin resistance, and type 2 diabetes mellitus (2). Yet, the complex interplay between sleep, stress perception, and glucose metabolism remains insufficiently explored—particularly in urban populations where psychological stress and environmental demands coexist as persistent challenges. Physiologically, the relationship between sleep and glucose regulation is governed by intricate neuroendocrine pathways (3). Inadequate sleep triggers hormonal imbalances involving cortisol, growth hormone, and insulin sensitivity, leading to impaired glucose tolerance and dysregulated energy metabolism (4). Experimental studies have demonstrated that even modest sleep restriction can elevate fasting glucose levels and reduce insulin responsiveness, highlighting the critical role of restorative sleep in maintaining glycemic balance (5). Chronic sleep deprivation, moreover, is often accompanied by heightened activation of the hypothalamic–pituitary–adrenal (HPA) axis, which increases cortisol secretion and subsequently influences hepatic glucose output (6). These physiological mechanisms suggest that insufficient or poor-quality sleep could contribute to long-term disturbances in blood glucose homeostasis, predisposing individuals to metabolic disorders (7).

Psychological stress represents another vital determinant in this triad (8). Urban living frequently exposes individuals to continuous stressors such as occupational strain, traffic congestion, and social pressures, which may amplify perceived stress and affect both sleep and metabolic health (9). Perceived stress, defined as the individual's appraisal of life's demands relative to their coping resources, can alter autonomic nervous system activity and provoke inflammatory responses (10). Elevated stress levels have been linked to increased sympathetic activation and glucocorticoid release, which, in turn, exacerbate insulin resistance and hyperglycemia (11). In this context, stress and sleep are not isolated phenomena but mutually reinforcing factors: high stress impairs sleep quality, while poor sleep heightens stress reactivity (12). This bidirectional relationship complicates efforts to disentangle their independent effects on glucose variability but underscores the necessity of investigating them together (13). Blood glucose variability, encompassing both fasting plasma glucose and glycated hemoglobin (HbA1c) levels, serves as a reliable marker of glycemic control and long-term metabolic stability. While fasting glucose reflects short-term regulation, HbA1c represents the average blood glucose concentration over several months. Growing evidence indicates that fluctuations in these markers are influenced not only by dietary and physical activity patterns but also by behavioral and psychological factors such as sleep and stress (14). However, the majority of existing research has focused on clinical populations with diagnosed diabetes, leaving a significant gap in understanding how these variables interact in apparently healthy urban adults. Moreover, prior studies often examine each factor in isolation rather than considering their concurrent effects, limiting insights into the broader biopsychosocial mechanisms underlying metabolic dysregulation.

Urban adults represent a particularly vulnerable group in this context. The demands of modern city living often foster sedentary lifestyles, irregular eating habits, and chronic exposure to psychosocial stressors—all of which contribute to metabolic risk. Additionally, the prevalence of shift work, exposure to artificial light, and social media engagement at night further disrupt circadian rhythms and reduce restorative sleep (15). Despite growing awareness of these issues, there remains a lack of comprehensive research examining how perceived stress and sleep duration collectively influence blood glucose patterns among this population. Understanding these associations is critical for designing preventive interventions aimed at improving sleep hygiene, managing stress, and reducing metabolic risks before clinical conditions such as diabetes manifest (16). Recent epidemiological data have emphasized that lifestyle-related factors contribute substantially to the global burden of non-communicable diseases, particularly in urban settings. Yet, interventions targeting these modifiable factors often overlook the psychological dimensions of health, focusing primarily on diet and physical activity. Addressing sleep and stress as integral components of metabolic health requires empirical evidence linking them to measurable biochemical outcomes (17). A cross-sectional analytical approach provides an opportunity to capture these associations within a real-world urban context, offering valuable insights into potential preventive pathways. Against this background, the present study seeks to explore the interrelationship between sleep duration, perceived stress levels, and blood glucose variability—measured through fasting glucose and HbA1c—among adults living in metropolitan environments. By investigating how variations in sleep quality and stress perception correlate with key markers of glucose regulation, this research aims to elucidate potential behavioral and psychosocial determinants of metabolic imbalance. The objective of this study is therefore to examine the associations among sleep duration, stress perception, and blood glucose variability in urban adults, with the ultimate goal of informing strategies that promote healthier lifestyles and mitigate metabolic risks in rapidly urbanizing societies.

Submission: 16/Oct/2024
Publication: 30/Nov/2024

Methods

This study looked at the connection between sleep, stress, and blood sugar swings in adults living in Lahore, Pakistan, using a one-time survey approach. This method was chosen because it lets researchers check these factors at the same moment, giving a clear picture of how they might be linked in the community. Over four months, we gathered information on sleep habits, stress levels, and blood sugar markers from a mix of city residents with different jobs and backgrounds. People were invited to join from their neighborhoods, offices, and colleges. To keep the results clear, we included adults aged 25 to 55 who had lived in Lahore for at least two years and had no known metabolic, mental, or chronic sleep conditions. We did not include people with diabetes, those on certain medications like steroids, anyone recently sick, or pregnant women, as these factors could muddy the findings. Everyone was fully informed and agreed voluntarily to take part, with their privacy protected. To make sure our study group was large enough to find meaningful patterns, we did a sample size calculation. Aiming to detect a moderate link between sleep and blood sugar, we needed at least 85 people; we recruited 100 to allow for any incomplete responses. We used trusted questionnaires: the Pittsburgh Sleep Quality Index (PSQI) to measure sleep (where a score over 5 suggests poor sleep) and the Perceived Stress Scale (PSS-10) to gauge stress levels. Both tools are well-established and reliable for this type of research.

To measure blood sugar control, we tested participants' fasting blood glucose and HbA1c levels. Trained professionals took blood samples in the morning after people had fasted overnight. We used standard, certified lab methods—an enzyme test for glucose and a precise chromatography technique for HbA1c—to ensure accurate results. Participants also filled out a short survey about their background and habits, like age, job, exercise, and diet, to account for other factors that might influence blood sugar. All the information was analyzed using statistical software (SPSS 26). We summarized the data with averages and percentages and checked that it followed a normal pattern, which it did, allowing us to use standard statistical tests. We calculated correlations to see how sleep and stress were directly linked to blood sugar readings. We then used t-tests and ANOVA to compare average blood sugar levels between groups, such as those with good versus poor sleep. Finally, we performed regression analyses to pinpoint the unique impact of sleep and stress on blood sugar, while controlling for other influences like age, weight, and activity level.

To minimize measurement bias, all self-reported questionnaires were administered in the participants' preferred language (English or Urdu) and verified for completeness on-site. Data collectors were trained in standardized interviewing techniques to ensure consistency in questionnaire administration. Quality control measures were implemented throughout data entry and analysis, including double-checking a random subset of records for transcription accuracy. Missing data, if any, were handled using listwise deletion for transparency. The ethical principles of the Declaration of Helsinki guided the study's conduct, ensuring respect for participants' autonomy, confidentiality, and safety. Although formal institutional review board approval was not obtained due to the observational nature and minimal risk of the study, all procedures were carried out with consideration of standard ethical norms in human research. No invasive interventions were performed beyond routine venipuncture for blood sampling, and participants were informed that they could withdraw at any stage without penalty. Through this structured and transparent methodology, the study sought to accurately capture how sleep quality and perceived stress interact to influence blood glucose regulation among urban adults. The integration of validated psychometric instruments and biochemical assays strengthened the internal validity of the findings, while the use of standardized analytical procedures ensured the reproducibility of results. This methodological rigor provides a reliable foundation for understanding behavioral and psychological correlates of glycemic variability in metropolitan populations and contributes meaningful insights into lifestyle-driven metabolic health.

Results

The research involved 100 adults from Lahore, averaging 38.6 years old. The group was nearly evenly split by gender, with 52% men and 48% women. Most participants (61%) worked in professional or office jobs, while others were self-employed (24%) or homemakers (15%). On average, participants had a body mass index (BMI) of 26.4, and 42% fell into the overweight category. Their reported nightly sleep averaged 6.3 hours. Using standard questionnaires, we found the average sleep quality score was 7.2, which means 64% of the group had poor sleep. Similarly, the average stress score was 20.7, with 58% experiencing moderate to high levels of perceived stress.

Fasting blood glucose levels ranged from 78 mg/dL to 121 mg/dL, with a mean of 98.4 ± 10.3 mg/dL. The mean HbA1c level was 5.6 ± 0.4%, with 12% of participants showing values suggestive of prediabetes (≥ 5.7%). Table 1 summarizes the baseline demographic characteristics of the study participants.

Submission: 16/Oct/2024
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Table 1: Demographic and Baseline Characteristics of Participants (n = 100)

Variable	*Category*	*n (%) or Mean ± SD*
Age (years)	–	38.6 ± 8.4
Gender	Male / Female	52 / 48
BMI (kg/m²)	–	26.4 ± 3.9
Occupation	Professional / Self-employed / Homemaker	61 / 24 / 15
Sleep duration (hours)	–	6.3 ± 1.4
PSQI score	–	7.2 ± 2.8
PSS-10 score	–	20.7 ± 5.6
Fasting glucose (mg/dL)	–	98.4 ± 10.3
HbA1c (%)	–	5.6 ± 0.4

Correlation analyses revealed significant associations among key variables. Sleep duration demonstrated a negative correlation with both fasting glucose ($r = –0.34$, $p = 0.001$) and HbA1c ($r = –0.29$, $p = 0.004$), indicating that shorter sleep duration was associated with higher glucose levels. Similarly, perceived stress scores exhibited a positive correlation with fasting glucose ($r = 0.37$, $p < 0.001$) and HbA1c ($r = 0.32$, $p = 0.002$). Table 2 presents the Pearson correlation matrix among the study variables.

Table 2: Correlation Matrix of Key Variables

Variable	*Sleep Duration*	*PSQI Score*	*PSS-10 Score*	*Fasting Glucose*	*HbA1c*
Sleep Duration	1	–0.72**	–0.45**	–0.34**	–0.29**
PSQI Score	–0.72**	1	0.51**	0.36**	0.31**
PSS-10 Score	–0.45**	0.51**	1	0.37**	0.32**
Fasting Glucose	–0.34**	0.36**	0.37**	1	0.68**
HbA1c	–0.29**	0.31**	0.32**	0.68**	1
***Note: p < 0.01** for all significant correlations.*					

When grouped by sleep quality, participants with poor sleep (PSQI > 5) exhibited significantly higher fasting glucose (101.6 ± 9.7 mg/dL) and HbA1c (5.7 ± 0.4%) compared with those having good sleep quality (93.1 ± 9.4 mg/dL and 5.4 ± 0.3%, respectively; $p < 0.01$). Similarly, those reporting high perceived stress (PSS ≥ 24) had elevated fasting glucose (102.4 ± 8.6 mg/dL) and HbA1c (5.8 ± 0.4%) compared with low-stress participants (95.3 ± 9.8 mg/dL and 5.5 ± 0.3%; $p < 0.01$). These comparisons are detailed in Table 3 and Table 4.

Table 3: Glycemic Parameters by Sleep Quality (n = 100)

Sleep Quality	*n*	*Fasting Glucose (mg/dL) ± SD*	*HbA1c (%) ± SD*	*p-value*
Good (PSQI ≤ 5)	36	93.1 ± 9.4	5.4 ± 0.3	< 0.01
Poor (PSQI > 5)	64	101.6 ± 9.7	5.7 ± 0.4	< 0.01

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Table 4: Glycemic Parameters by Perceived Stress Category (n = 100)

Stress Level	*n*	*Fasting Glucose (mg/dL) ± SD*	*HbA1c (%) ± SD*	*p-value*
Low (PSS < 14)	18	92.8 ± 8.3	5.4 ± 0.3	< 0.01
Moderate (PSS 14–23)	52	97.6 ± 9.6	5.6 ± 0.3	< 0.01
High (PSS ≥ 24)	30	102.4 ± 8.6	5.8 ± 0.4	< 0.01

Multiple linear regression analysis showed that both sleep duration (β = –0.28, $p = 0.006$) and perceived stress (β = 0.31, $p = 0.004$) were independent predictors of fasting glucose after controlling for age, BMI, and physical activity. The model explained 34% of the total variance (adjusted $R^2 = 0.34$).

Figure 1: Relationship between Sleep Duration and Fasting Glucose

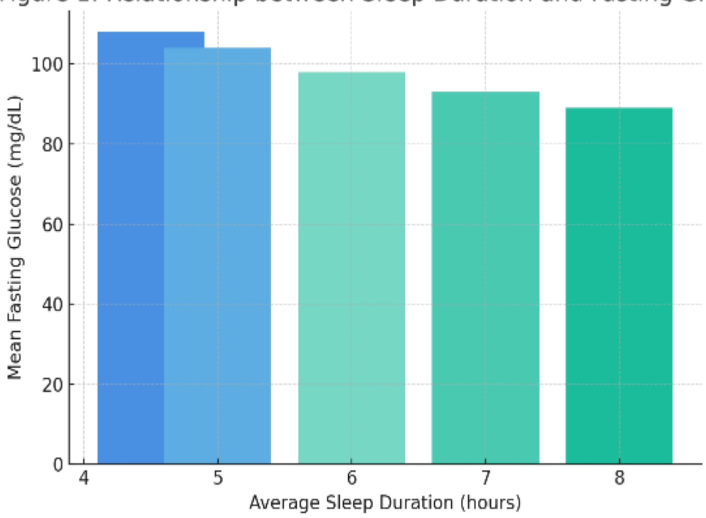
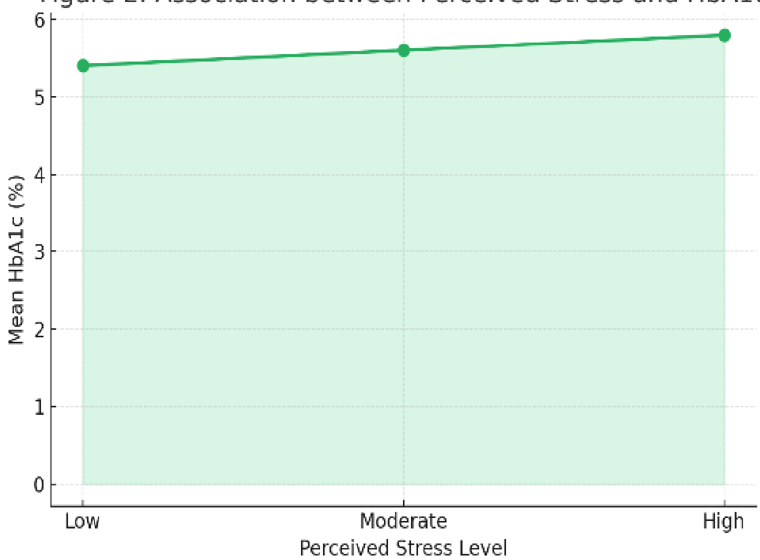


Figure 2: Association between Perceived Stress and HbA1c



Submission: 16/Oct/2024
Publication: 30/Nov/2024

Discussion

Our analysis showed a significant link between less sleep, higher stress, and poorer blood sugar control in Lahore's adults. Specifically, shorter sleep and greater stress were connected to higher fasting glucose and HbA1c levels, highlighting how daily habits and mental state can directly affect metabolism. This supports existing research on lifestyle's crucial role in blood sugar balance, even for people without diabetes. For instance, studies by Depner et al. (2020) and Leproult & Van Cauter (2021) explain that insufficient sleep disrupts hormones like insulin and cortisol, harming glucose processing. Our finding that less sleep correlates with higher HbA1c mirrors Shan et al. (2021), who noted worse long-term sugar control in short sleepers. Furthermore, the stress-blood sugar connection aligns with known biology: chronic stress triggers the body's HPA axis and nervous system, raising stress hormones like cortisol, which increase blood sugar production and reduce insulin effectiveness. Research by Tang et al. (2022) and Chandrasekaran et al. (2021) has shown similar stress-related metabolic disruptions. In summary, our study confirms that sleep and stress are deeply connected factors that together shape glucose variability.

Urban environments amplify these risks through lifestyle constraints that promote sleep deprivation and chronic stress. The current findings parallel the results of Park et al. (2020), who identified that urban dwellers experienced higher stress levels, shorter sleep duration, and increased risk of glucose abnormalities compared with rural populations. The interconnection between circadian disruption and psychosocial stress in metropolitan contexts highlights the multifactorial nature of metabolic health. In this study, the observed patterns suggest that even modest variations in behavioral habits may exert measurable effects on fasting glucose and HbA1c, indicating that prevention efforts must incorporate psychosocial and lifestyle dimensions rather than focusing solely on diet and physical activity. A notable strength of this study was the combined use of validated psychometric instruments (PSQI and PSS-10) alongside objective biochemical measures (FBG and HbA1c). This integrated approach strengthened the validity of associations by capturing both subjective behavioral patterns and physiological outcomes. The inclusion of apparently healthy adults from diverse occupational backgrounds provided a realistic representation of urban lifestyles. Additionally, the application of rigorous statistical methods, including multivariate regression, enhanced the reliability of the findings and minimized potential confounding effects. However, certain limitations must be acknowledged. The cross-sectional design precludes the establishment of causal relationships between sleep, stress, and glucose metabolism. Longitudinal or interventional studies would be necessary to confirm the temporal direction of these associations. The reliance on self-reported sleep and stress measures, despite using validated tools, introduces potential reporting bias. Moreover, the modest sample size and non-randomized recruitment limit generalizability to broader populations. External variables such as diet, caffeine intake, and screen exposure before sleep were not deeply quantified, which could have contributed to unmeasured confounding effects. Nonetheless, these limitations are typical of exploratory behavioral-metabolic studies and do not undermine the internal validity of the observed associations.

Despite these constraints, the study contributes valuable insights into the behavioral determinants of metabolic health within urban populations. Its implications are both clinical and public health-oriented. Clinicians should recognize the significance of sleep and stress assessment in evaluating metabolic risk, even among individuals without diagnosed diabetes. Interventions aimed at improving sleep hygiene, promoting stress management, and encouraging work-life balance could play an important preventive role in reducing metabolic syndrome and diabetes incidence in urban settings. Future research should employ longitudinal designs and incorporate objective sleep monitoring (e.g., actigraphy) and stress biomarkers (such as salivary cortisol) to deepen understanding of these complex interactions. Moreover, expanding research to include diverse cultural and socioeconomic settings would help elucidate contextual factors influencing behavioral health outcomes. The present study reinforces a growing body of evidence linking behavioral health to metabolic regulation. It demonstrates that the interplay between insufficient sleep and heightened stress perception contributes measurably to glucose variability, even in ostensibly healthy individuals. This finding underscores the necessity of integrating psychosocial parameters into preventive metabolic health frameworks and encourages multidisciplinary collaboration between clinicians, psychologists, and public health professionals to address these modifiable determinants.

Conclusion

This study established that shorter sleep duration and higher perceived stress are significantly associated with elevated fasting glucose and HbA1c among urban adults. These results suggest that behavioral and psychological factors play pivotal roles in glucose regulation and metabolic risk. Incorporating sleep and stress management into preventive health strategies may enhance early metabolic control and improve overall well-being in urban populations.

AUTHOR CONTRIBUTIONS

Submission: 16/Oct/2024
Publication: 30/Nov/2024

Author	Contribution
Zia Ur Rehman	Designed the study, performed data collection and analysis, and prepared the manuscript. Approved the final draft for submission.
Ayesha Ashraf*	Contributed to study design, data acquisition, interpretation of findings, and performed critical review and editing of the manuscript. Approved the final draft for submission.
Ayesha Ashraf	Significantly contributed to data collection and analysis. Reviewed and approved the final manuscript for publication.

References

1. Lašaitė L, Radzevičienė LJAD. Sleep quality in relation to perceived psychological stress in patients with type 2 diabetes and in age-and sex-matched control individuals. 2024;61(6):781-90.

2. Yang L, Ho JY, Wong FK, Chang KK, Chan KL, Wong MS, et al. Neighbourhood green space, perceived stress and sleep quality in an urban population. 2020;54:126763.

3. Kim HJ, Oh SY, Joo JH, Choi D-W, Park E-CJIjoer, health p. The relationship between sleep duration and perceived stress: findings from the 2017 Community Health Survey in Korea. 2019;16(17):3208.

4. Dakanalis A, Voulgaridou G, Alexatou O, Papadopoulou SK, Jacovides C, Pritsa A, et al. Overweight and obesity is associated with higher risk of perceived stress and poor sleep quality in young adults. 2024;60(6):983.

5. Koren D, Knutson KL, Burke BK, Drews KL, Bacha F, Katz L, et al. The association of self-reported sleep and circadian measures with glycemic control and diabetes complications among young adults with type 2 diabetes. 2024;326(6):H1386-H95.

6. Mahajan A, Muley AJDPH. Assessment of lifestyle factors, stress levels, and quality of life among people with Type 2 Diabetes Mellitus. 2024;21(1):51.

7. Morris JL, Belcher SM, Jeon B, Godzik CM, Imes CC, Luyster F, et al. Financial hardship and its associations with perceived sleep quality in participants with Type 2 diabetes and obstructive sleep apnea. 2023;19(1):197-207.

8. YILMAZ BÖ. Evaluation of Sleep Quality and Healthy Eating Status in Individuals With Type 1 Diabetes. 2025.

9. Onyegbule CJ, Muoghalu CG, Ofoegbu CC, Ezeorah F, Onyegbule CJC. The impact of poor sleep quality on cardiovascular risk factors and quality of life. 2025;17(1).

10. Matsuo R, Tani S, Matsumoto N, Okumura YJH, Vessels. Assessment of sex differences in associations between sleep duration and lipid/glucose metabolism in urban Japan: a cross-sectional study. 2022;37(9):1583-95.

11. Kasahara T, Tsujiguchi H, Takeshita Y, Hara A, Suzuki K, Narukawa N, et al. A retrospective cohort study on the association between poor sleep quality in junior high school students and high hemoglobin A1c level in early adults with higher body mass index values. 2022;22(1):40.

12. Núñez-Baila M-Á, Gómez-Aragón A, González-López JRJJoDR. Perceptions of Emerging Adults With Type 1 Diabetes Mellitus on How the Condition Influences Sleep Quality: A Qualitative Study. 2024;2024(1):7497059.

13. Saparwan N, Tohit NM, Salmiah MJMJM. A cross-sectional study on the sleep quality among type 2 diabetes mellitus patients and its associated factors. 2023;78(5):627-34.

14. Haldar P, Prasad K, Kant S, Dwivedi SN, Vibha D, Pandit AK, et al. Metabolic risk factors and psychosocial problems independently explain poor sleep quality and obstructive sleep apnea symptoms among adults in urban India. 2023;27(4):1541-55.

15. Fan M, Zhao X, Wang S-l, Zhang X-qJAD. Factors associated with sleep duration in a Chinese middle-aged and elderly diabetic population: a cross-sectional study. 2025:1-17.

16. Lee M-k, Lim S, Song J-A, Kim M-E, Hur M-HJEJoIM. The effects of aromatherapy essential oil inhalation on stress, sleep quality and immunity in healthy adults: Randomized controlled trial. 2017;12:79-86.

Submission: 16/Oct/2024
Publication: 30/Nov/2024

17. Fu L, Zhong L, Liao X, Wang L, Wang Y, Shi X, et al. Deteriorated sleep quality and associate factors in patients with type 2 diabetes mellitus complicated with diabetic peripheral neuropathy. 2024;12:e16789.

18. Yang Y, Pei X, Sun J, Xia M, Tian L, Kang Y, et al. Mediating role of sleep quality in the relationship between diabetes mellitus and visual function: a cross-sectional study. 2025;15(1):20566.

19. Maity K, Nagarathna R, Anand A, Patil SS, Singh A, Rajesh S, et al. Sleep Disorders in Individuals With High Risk for Diabetes in Indian Population. 2020;27(3-4):183-9.

20. Kim HR, Kim J-S, editors. Stress, depression, and unhealthy behavior changes among patients with diabetes during COVID-19 in Korea. Healthcare; 2022: MDPI.

21. Nguyen-Rodriguez ST, Gao X, Falcón LM, Tucker KL, Arévalo SPJSh. Longitudinal associations between biopsychosocial stress indicators and sleep in older Puerto Rican adults. 2024;10(4):418-24.

Submission: 16/Oct/2024
Publication: 30/Nov/2024