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Sleep Quality and Its Association with the Risk of Type 2 Diabetes in Young Adults in a Primary Care Centre in Mexico

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Abstract

Introduction: In Mexico, 18.3% of adults over 20 years of age have been diagnosed with Type 2 Diabetes (T2D). Evidence suggests that sleep quality and duration are related to metabolic diseases, including the risk of developing T2D. A cross-sectional, analytical study was conducted in healthy adults, aged 18 to 40 years old, male and female, with normal weight, overweight and grade I obesity. Subjects with T2D, pre-diabetes, depression, chronic pain and sleep apnoea were excluded. The FINDRISC and Pittsburgh Sleep Quality Index instruments were used. A multiple binary logistic regression model was constructed including male sex, obesity, overweight and poor sleep quality, obtaining exponentials of β (Exp B), 95% CI and p. of 165 subjects, 52.3% were female. Poor sleep quality was 38.2%. The adjusted model showed an association between poor sleep quality and risk of T2D with an Exp B of 2.46 (95% CI: 1.85 - 5.21) and $p < 0.05$. The findings highlight the importance of implementing efficient non-pharmacological and pharmacological strategies to improve sleep quality and control overweight and obesity in healthy individuals in primary care settings.

Keywords

Sleep Quality, Diabetes Mellitus, Risk Factors, Adult

1. Introduction

Type 2 Diabetes (T2D) is a major non-communicable disease that impacts 11.1% of the population worldwide and is a significant cause of death in Western countries [1] [2]. Mexico ranks eighth in the world for diabetes, affecting 18.3% of the adult population, based on data from the Instituto Nacional de Estadística y Geografía (National Institute of Statistics and Geography, INEGI, for its acronym in Spanish) [3] [4]. Strategies have focused mainly on pharmacological strategies and non-pharmacological interventions such as dietary modification, increased physical activity and self-care education. Sleep quality and time have not been systematically integrated as part of these strategies for healthy adults. Evidence shows the impact of sleep on glycaemic homeostasis and insulin sensitivity [5].

Sleep quality involves elements such as sleep latency, hours of sleep, sleep continuity, nocturnal awakenings and alertness phases [6]-[8]. As a modifiable factor, its integration into preventive measures against Type 2 Diabetes is of great importance [9]. Several clinical investigations have pointed to a decrease in the risk of pre-diabetes and complications due to changes in the quantity and quality of sleep [9] [10].

Chronic lack of sleep (less than six hours per night), as well as excessive sleep (more than ten hours), increases the risk of developing cardiovascular and metabolic diseases [11] [12]. This is explained by the fact that hormones that regulate glucose and appetite, such as growth hormone, cortisol, leptin and ghrelin, are modulated by sleep [13]. The quality and duration of sleep affect the release of these hormones, influencing glucose tolerance and hunger control; therefore, sleep plays a key role in metabolic hormone regulation [14] [15]. Experimental studies have shown that sleep restriction and circadian rhythm disruption can reduce basal metabolic rate and lead to insulin resistance and hyperglycaemia. A single night of deprivation can alter the metabolic profile, elevating lipids and amino acids related to energy and neuronal metabolism, confirming the impact of sleep on metabolic balance [16] [17].

In murine models, six hours of fasting sleep deprivation resulted in increased hepatic glucose production, accumulation of triglycerides in the liver and elevation of metabolites related to lipid oxidation [18]. In addition, overexpression of genes involved in lipogenesis was observed, suggesting that sleep deprivation-induced hepatic steatosis contributes to the development of hepatic insulin resistance [18] [19]. In this context, international bodies in diabetes and metabolism have noted that increasing sleep by one hour per night for several weeks can improve insulin sensitivity, so that seven to nine hours of sleep per day is recommended to maintain good metabolic health [6] [8] [20] [21].

Sleep quality is linked to other risk factors for T2D [12] [22]. Recent studies have documented that poor quality and insufficient duration (less than six hours per night) are associated with decreased insulin sensitivity, impaired insulin secretion and increased overall metabolic risk [22]-[24]. These conditions include fasting hyperglycaemia, insulin resistance and a chronic low-grade inflammatory state [11] [16] [22]. In addition, sleep disruption alters the balance of stress-regulating compounds, satiety and appetite, leading to increased caloric intake, weight gain and visceral fat accumulation, contributing to the development of obesity and risk of T2D [25] [26].

Furthermore, irregular sleep patterns are associated with metabolic and mood disorders, such as depression and anxiety [10]. Workers with irregular schedules, especially those working night shifts, have been identified as having increased insulin resistance due to alterations in their circadian rhythms [11] [12].

Although several studies have shown an association between sleep quality and the risk of metabolic disorders, including insulin resistance and the presence of T2D [14] [16] [27]-[29], most of these investigations have been conducted in English, Asian or Latino populations with prediabetes and T2D [28] [30]-[32]. The sociodemographic, epigenetic and cultural characteristics of the Mexican population require specific clinical studies. Likewise, social inequalities, poor dietary habits and unhealthy sleep habits [7] [33] [34], characterised by irregular schedules, nocturnal exposure to screens and shorter sleep duration [35] [36]. Added to this is the genetic influence, as variants such as SLC16A11 and polymorphisms in genes such as TCF7L2, present in a high percentage of the Mexican population, have been identified as being associated with a risk of developing T2D [37] [38]. Genes related to overweight and obesity have even been identified in Mexican children and adolescents since childhood [39] [40], suggesting a metabolic vulnerability from early stages of life. Therefore, the aim of the present study is to determine the association between sleep quality and the risk of T2D in healthy young Mexican adults.

2. Methodology

A cross-sectional and analytical study was conducted in a primary care centre in Mexico, which was the Family Medicine Unit No. 64 "Tequesquinahuac" (UMF, for its acronym in Spanish), of the Instituto Mexicano del Seguro Social (Mexican Social Security Institute, IMSS, for its acronym in Spanish), between February and April 2024. Men and women between 18 and 40 years of age, with normal weight, overweight, G1 obesity and without medical comorbidities were included. Subjects with a previous diagnosis of pre-diabetes, type 2 diabetes, sleep apnoea, psychiatric disorders such as anxiety or depression, chronic pain and use of medications that may alter sleep or metabolism such as antidepressants, hypnotics, anticonvulsants and steroids (corroborated in digital dossier) were excluded.

The sample was calculated with the OpenEpi software version 3.01 [15], using

a formula for difference of proportions, considering an alpha of 0.05 and a 1-B of 80%. Considering an estimated prevalence of 14.9% [41] for sleep quality and 12.4% [42] for diabetes risk, an n = 170. A ratio of exposed with outcome and not exposed with outcome of 1:1 was considered. Non-probability sampling by consecutive cases was used. The sample was collected from subjects attending scheduled and unscheduled appointments at the family medicine outpatient clinic.

The FINDRISC questionnaire [16], validated in a Hispanic population, was used to assess the risk of developing T2D. For the assessment of sleep quality, the Spanish version of the Pittsburgh Sleep Quality Index [17] was used, which rates: without problem, deserves medical attention, requires medical attention with medical treatment, and severe problem. For statistical purposes, it was dichotomised into the following: good sleep quality (score ≤ 5) and poor sleep quality (score > 5).

For the descriptive analysis, qualitative variables (sex, educational level, occupation, marital status, body mass index and hereditary family history of diabetes) were expressed as frequencies and percentages. For quantitative variables (age, weight, height, and abdominal circumference), their distribution was assessed by using the Kolmogorov-Smirnov test ($p > 0.05$), as well as the skewness (values between −0.5 and 0.5) and kurtosis (values between −0.2 and 2) criteria. Since a free distribution was observed, median and interquartile range (25 - 75) were reported. Sociodemographic and clinical characteristics were contrasted with sleep quality (poor and good) and risk of T2D by using Pearson's Chi-square tests and linear trend tests, according to *ad hoc* statistical assumptions. To compare quantitative variables with two groups, the Mann-Whitney U test was used and a value of $p < 0.05$ was considered as a factor of dependence.

To determine the association between sleep quality and T2D risk, Pearson's Chi-square test was used, with OR, 95% CI and $p < 0.05$ considered as factor dependence. In addition, a multiple binary logistic regression model was constructed including male sex, overweight or obesity, hereditary family history of T2D and poor sleep quality, obtaining Exp B (exponential of β), 95% CI and $p < 0.05$ as factor dependence. Covariates with statistical significance, tendency to statistical association (0.05 - 0.075) and biological plausibility or available knowledge for risk of T2D were considered. SPSS version 23 was used.

3. Results

Of the total number of participants, 62.4% were female. In relation to sleep, 38.8% had a sleep quality that warranted medical attention and treatment. Regarding the risk of developing Type 2 diabetes, the moderate level was the most frequent, with 32.7% of cases.

Regarding clinical and sociodemographic variables associated with sleep quality, it was found that overweight, undergraduate schooling and a family history of first-line type 2 diabetes were associated with poor sleep quality with $p = 0.038$, $p = 0.010$, and $p = 0.034$, respectively (see **Table 1**).

Table 1. Clinical and sociodemographic characteristics associated with sleep quality in young adults in Mexico.

Parameter	Poor sleep quality n = 119 (%)	Good quality of sleep n = 46 (%)	*p-value*
Age IQR (25, 75)	31 (25, 36.5)	31 (24.5, 31)	0.473[c]
Sex			
Female	80 (62)	23 (63.9)	0.837[b]
Male	49 (38)	13 (36.1)	
Marital status			
Married	59 (45.7)	9 (25)	0.139[a]
Single	61 (47.3)	26 (72.2)	
Divorced	9 (7)	1 (2.8)	
Schooling			
Primary	0 (0)	1 (2.8)	
Secondary	28 (21.7)	12 (33.3)	0.010[a]
High school	40 (31)	14 (38.9)	
Bachelor's degree	61 (47.3)	9 (25)	
Employment status			
Full time	90 (69.8)	27 (75)	
Part-time	13 (14.1)	5 (13.9)	0.334[a]
Night work	4 (3.1)	0 (0)	
Unemployed	22 (17)	4 (11.1)	
BMI categorised			
Normal	41 (31.8)	19 (52.8)	0.038[a]
Overweight	55 (42.6)	11 (30.6)	
Obese	33 (25.6)	6 (16.6)	
IQR weight (25.75), kg	70 (60, 85)	65.5 (60, 75.75)	0.296[c]
Size IQR (25.75), cm	162 (156, 170)	160 (156, 168.25)	0.521[c]
Abdominal circumference IQR (25.75), cm	90 (82, 94)	86 (80, 92)	0.205[c]
HF history T2D			
n (%)			
Not present	12 (9.3)	8 (22.2)	0.020[a]
First line	69 (53.5)	13 (36.1)	
Second line	48 (37.2)	15 (41.7)	

n = total; % = percentage; IQR = Interquartile Range; a = linear trend test; b = Chi-square; Pearson's test; c = Mann-Whitney U test; HF = hereditary family history; T2D = Type 2 Diabetes.

Regarding clinical and sociodemographic parameters associated with the risk of developing T2D, age 34 years old, undergraduate education, overweight, weight > 72 kg, abdominal circumference > 90.5 cm and the presence of a first-line HF history of T2D were associated with risk of T2D, with a $p \leq 0.05$ (see Table 2).

Table 2. Clinical and sociodemographic characteristics of healthy Mexican adults with risk of T2D.

Parameter	At risk of diabetes n = 69 (%)	Not at risk of diabetes n = 96 (%)	*p*-value	OR with 95% CI
Age IQR (25.75)	34 (27, 38)	30 (24.5, 37)	<0.05[c]	
Sex				
Female	54 (69.2)	49 (54.3)	0.87[b]	2.9 (0.919 - 3.312)
Male	24 (30.8)	38 (43.7)		
Marital status				
Married	32 (41)	36 (41.4)	0.525[a]	-----
Single	39 (50)	51 (52.2)		
Divorced	7 (9)	3 (3.4)		
Schooling				
Primary	1 (1.4)	0 (0.0)		
Secondary	14 (17.9)	26 (29.9)	<0.05[a]	----
High school	21 (26.9)	33 (37.9)		
Bachelor's degree	34 (53.8)	38 (32.2)		
Working status				
Full-time	55 (70.5)	62 (71.3)		----
Part-time	5 (6.4)	13(14.9)	0.215[a]	
Night work	1 (1.3)	3 (3.4)		
Unemployed	17(21.8)	9 (10.4)		
BMI categorised				
Overweight	41 (52.6)	25 (28.7)	<0.05[a]	----
Normal	16 (20.5)	44 (50.6)		
Obese	21 (26.9)	18 (20.7)		
IQR weight (25, 75)	72 (64.75, 86.5)	64 (58, 78)	<0.05[c]	----
Size IQR (25, 75)	162 (156, 170)	161.5 (156, 170)	0.375[c]	----
Abdominal circumference				
IQR (25, 75)	90.5 (85, 96)	86 (80, 91)	<0.05[c]	
HF history of T2D				----
Not present	4 (5.1)	16 (18.4)	<0.05[a]	
First line	46 (59%)	36 (41.4)		
Second line	28 (35.9)	35 (40.2)		

n = total; % = percentage; IQR = Interquartile Range; a = Linear trend test; b = Pearson's chi-square; c = Mann-Whitney U test; OR = Odds Ratio; CI = Confidence Interval; HF = Hereditary Family history; T2D = Type 2 Diabetes.

Poor sleep quality was associated with the risk of T2D with an OR of 3.15 (95% CI 1.29 - 6.49) and $p \leq 0.05$ (see Table 3).

Adjusted analysis identified three factors associated with risk of T2D. Overweight or obesity, female sex and poor sleep quality showed an OR of 4.871 (95% CI, 2.275 - 10.430, $p < 0.05$), OR of 2.784 (95% CI, 1.339 - 5.786, $p < 0.05$) and OR of 2.462 (95% CI, 1.037 - 5.846, $p < 0.05$), respectively (see Table 4 and Figure 1).

Table 3. Association between sleep quality and risk of Type 2 diabetes in young adults in Mexico.

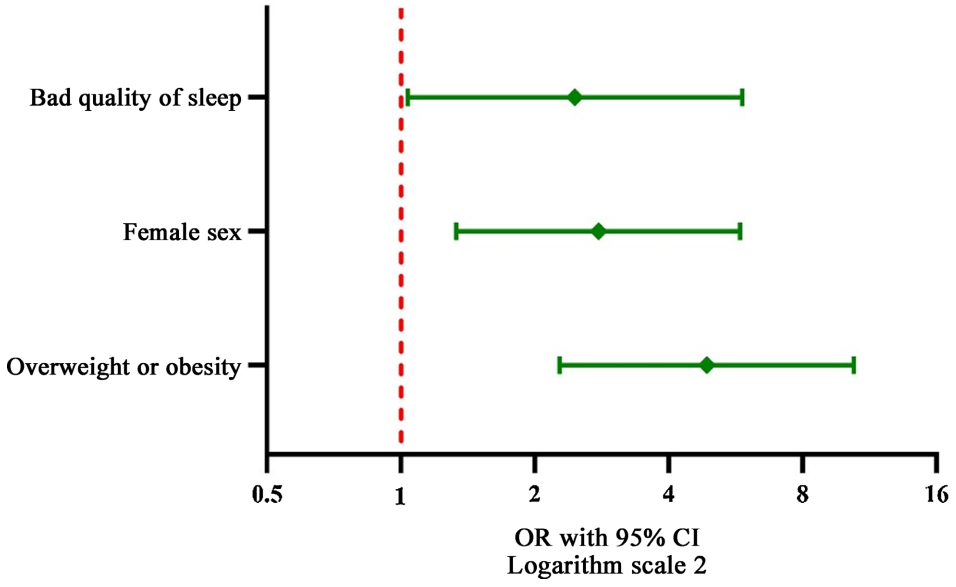
Sleep quality	With risk of Type 2 diabetes n = 78 (%)	No risk of T2D n = 87 (%)	OR with 95% CI	*p-value*
Poor	68 (87.2)	61(70.1)	3.15 [1.2 9- 6.49][a]	<0.05
Good	10 (12.8)	26 (29.9)		

n = total; % = percentage; a = Pearson's chi-square; CI = Confidence Interval; OR = Odds Ratio; T2D = Type 2 Diabetes.

Table 4. Multivariate model. Risk factors associated with the risk of Type 2 Diabetes in young adults in Mexico.

Logistic regression	Parameter	β	Wald	p	Exp β with 95% CI
Nagelkerke's $R^2 = 0.21$ Overall percentage = 52.7% Hosmer-Lemeshow test = 0.60	Intercept	−2.501	19.494	<0.05	---------
	Overweight or obese	1.574	15.975	<0.05	4.82 (2.23 - 10.44)
	Female sex	1.024	7.522	<0.05	2.78 (1.33 - 5.78)
	Poor sleep quality	.901	4.168	<0.05	2.46 (1.03 - 5.84)

CI = Confidence Interval; % = percentage; β = regression coefficient; R^2 = coefficient of determination; Exp β = exponential of β.



Source: own, Forest Plot representing the OR with 95% CI of the factors associated with risk of Type 2 Diabetes.

Figure 1. Multivariate model. Risk factors associated with risk of T2D.

4. Discussion

Among the main sociodemographic findings of this study, a predominance of

women was found, which is explained by the population composition in Mexico based on data from INEGI [1] [2], which shows a majority of women in the population pyramid. This is consistent with research that compared the experiences of women and men with T2D in rural and urban areas. They found a higher proportion of women affected by this disease [3].

Regarding sleep quality, it was found that most participants required medical attention and treatment based on the measurement instrument. This situation is similar to that reported by Mexican health institutions, which estimate that more than 30% of the population has sleep-related problems [4]-[6]. Coincidentally, in a study in a Latin American population that associated sleep quality and daytime sleepiness in university students, they reported that 73.6% had a sleep quality that required medical attention [7].

In this study, healthy subjects were found to have a moderate risk of T2D ($\leq$14 points on the FINDRISC scale). This aligns with the global projection that 12.5% of adults will have diabetes by 2045 [8] [9]. The results are consistent with a study of Latina health workers, which aimed to determine their risk of Type 2 diabetes, and found that participants were at moderate risk of developing this disease [10].

In relation to BMI, this study found that overweight people had a higher risk of poor sleep quality. Based on data from sleep research institutions in Mexico, sleep deprivation may increase the consumption of caloric foods, which favours overweight and obesity [6]. Similarly, a study in a Mexican university population reported a significant association between body mass index and daytime sleepiness, with a $p\text{-}value < 0.05$ [11].

Conversely, an association was found between abdominal girth and poor sleep quality. This is consistent with evidence that sleep restriction raises cortisol levels, alters the circadian cycle and inhibits lipid mobilisation, thus favouring the accumulation of abdominal fat. This visceral fat not only affects metabolic and respiratory function, but also contributes to the development of sleep apnoea, which in turn impairs sleep quality and perpetuates hormonal and metabolic imbalance [12]-[15]. However, a study in Peruvian workers linking sleep quality and metabolic syndrome did not find this association, possibly due to differences in measurement methods or in the sociodemographic characteristics of the participants [16].

Age over 34 years old was also associated with poor sleep quality. International organisations agree that age over 45 represents a threshold at which the risk of developing Type 2 diabetes increases markedly, due to a combination of reduced insulin secretion and resistance, loss of muscle mass, gain of visceral fat and accumulation of chronic metabolic and inflammatory diseases [17] [18]. This is consistent with research in a sample of young American adults, which shows that age, especially after 40 years old, is an independent risk factor for developing Type 2 diabetes [19].

In the present research, bachelor's degree education was associated with poor sleep quality. People with higher education tend to be exposed to higher levels of

academic or work-related stress, greater cognitive load and responsibilities associated with their profession, which can activate the hypothalamic-pituitary-adrenal axis, leading to an increase in the release of cortisol, a hormone that interferes with normal sleep architecture [20]-[22]. In addition, this group tends to have greater use of electronic devices, longer working hours and exposure to artificial lights at night, factors that alter the circadian rhythm and make it more difficult to reconcile and maintain sleep [23]. This contrasts with a study of medical students, which focused on determining factors related to sleep quality and found that students in their final year had the lowest levels of restorative sleep, showing a negative relationship between academic progress and sleep quality [24].

This study found an association between a hereditary family history of T2D in first-degree relatives and the risk of developing the disease. The literature supports this relationship as individuals with a family history show 30% - 70% higher risk, even adjusting for BMI and lifestyle [20]. This is explained by the fact that shared genetic factors, including variants in genes such as TCF7 L2, affect insulin secretion and sensitivity, as well as an altered adipokine profile that favours insulin resistance [25] [26]. A study in Mexico reported an OR of 2.44 (95% CI 1.32 - 4.50) for those with a maternal history and a 75.7% chance of developing the disease when both parents were diabetic [27].

In this study, BMI in the obese category was associated with the risk of developing T2D. National and international evidence shows that obesity, especially when severe or long-standing, increases the risk of developing T2D. This is due to excess adipose tissue, which promotes insulin resistance through the release of free fatty acids and pro-inflammatory cytokines [28]-[30]. Additional studies corroborate that Mexican participants with type II and III obesity had an increased risk of T2D, with a particularly high risk in those with a BMI ≥ 40 (OR = 18.7; $p < 0.001$) [31].

Body weight was also associated with the risk of developing Type 2 diabetes. Based on international diabetes bodies, it is estimated that approximately 85% of patients with Type 2 diabetes are overweight or obese, highlighting the strong association between excess body weight and this disease. In addition, mechanisms such as chronic inflammation of adipose tissue alter the production of protective adipokines such as adiponectin, decreasing their insulin-sensitising effect and leading to an unfavourable metabolic state [32] [33]. Coincidentally, a study in a Mexican population, whose main objective was to determine the 10-year risk of Type 2 diabetes, found that 73.33% of participants with obesity were at high risk of developing Type 2 diabetes according to the FINDRISC scale, which reinforces the usefulness of BMI as an indicator of metabolic risk [34].

Regarding the main objective of the present study, we identified that participants with poor sleep quality had a threefold increased risk of developing Type 2 diabetes in the simple and adjusted models. This can be explained by several pathophysiological mechanisms; poor sleep quality and insufficient sleep duration increase cortisol secretion, which leads to insulin resistance and favours visceral fat

accumulation. In addition, the sympathetic nervous system is activated, and appetite hormones (leptin and ghrelin) are altered, contributing to weight gain. These conditions lead to chronic low-grade inflammation and circadian rhythm imbalances, affecting glucose regulation and pancreatic function [23] [30] [35] [36]. These results are consistent with those reported in a longitudinal study in the UK, which concluded that both sleep quality and its changes over time influence the risk of developing Type 2 diabetes, with an OR of 1.34; 95% CI: 1.22 - 1.47, especially when sleep duration is also considered [37]. Similarly, an Asian population was analysed where the combination of poor sleep quality and short sleep duration was found to significantly increase the risk of diabetes compared to those with adequate sleep with an OR of 1.47; 95% CI: 1.26 - 1.71 [38]. It is worth mentioning that the above-mentioned research studied subjects with prediabetes or T2D.

In the adjusted model, overweight or obesity, female sex and first-degree hereditary family history increased the likelihood of developing T2D. The strongest association was observed between being overweight and obesity. In addition to inflammation and insulin resistance, obesity alters pancreatic β-cell function, contributing to a progressive deterioration of insulin secretion. Recent studies have also shown that individuals with obesity have alterations in the gut microbiome, which may influence glucose homeostasis through immunological and metabolic mechanisms. These alternative pathways strengthen the interpretation of BMI as a robust, multifactorial marker of T2D risk [29] [39]-[41]. Recent studies, such as that of Liu *et al.*, found that adults with obesity have a three- to six-fold increased risk of developing T2D, depending on their metabolic profile, which supports the magnitude of the effect observed in the present study [42].

In contrast, hereditary family history also showed a significant association, suggesting an important genetic burden in the development of the disease in healthy Mexican subjects. This finding is consistent with the results of a European study that identified that people with a family history of T2D have a two-fold increased risk of developing the disease, even after adjusting for variables such as BMI and lifestyle habits. Inheritance of certain genetic variants could affect both insulin production and efficacy, as well as pancreatic β-cell function [43]-[45].

Finally, male sex was also associated with T2D risk in healthy adults. This is interpreted by the differences in hormonal and body fat distribution between men and women. Several studies, such as the one conducted by Wang *et al.*, in an Asian population, have shown that postmenopausal women are more prone to metabolic dysfunction, while in men the risk tends to increase at younger ages. These patterns suggest that preventive strategies should be tailored to gender and consider underlying biological factors [46]-[48].

The findings of this study are consistent with recent research showing an association between sleep quality and risk of metabolic disturbances, even after adjusted modelling. In 2023, a study in an English population, which aimed to identify the risk of T2D associated with sleep quality using regression models adjusted

for age, sex, educational level, lifestyle and comorbidities, reported that poor sleep quality increases the risk of developing T2D by 45% (HR = 1.45; 95% CI: 1.09 - 1.92) [49]. Similarly, a study in an Asian population used multivariate logistic regression and found that poor sleep quality, together with obesity, male sex and polycystic ovary syndrome, was significantly associated with pre-diabetes [50].

Limitations of the present study include its cross-sectional design, which prevents the establishment of a causal relationship between poor sleep quality and the risk of developing Type 2 diabetes. In addition, the information was collected through self-administered questionnaires, which may lead to recall or interpretation biases. The sample was limited to persons attached to a single medical unit, which reduces the generalisability of the results to other populations.

The strength of this study is the use of multivariate analysis, which allowed for the control of the effect of confounding factors and strengthened the validity of the association observed between poor sleep quality and the risk of developing T2D. In addition, instruments validated in the Hispanic population, such as the Diabetes Risk Index (FINDRISC) and the Pittsburgh Sleep Quality Index (PSQI), were used, which confer greater precision in the measurement of the variables. Finally, the inclusion of a sample of young and apparently healthy adults also adds value by focusing on a population where preventive intervention is still possible.

5. Conclusion

The findings of this research suggest an association between poor sleep quality and the risk of developing T2D in the population assessed. These findings highlight the need to implement non-pharmacological and pharmacological strategies aimed at improving sleep quality, which could also contribute to the reduction of overweight and obesity in healthy individuals. In primary care centres, it is necessary to incorporate interventions such as the promotion of sleep hygiene, the assessment of family history and the control of harmful habits, such as excessive use of screens and eating food before bedtime. Another viable option, at the primary level of care, is to implement self-care dialogues between patients and healthcare professionals for sleep hygiene and recommendations to reduce the risk of diabetes. These actions are especially relevant in women and should be part of preventive programmes aimed at reducing the burden of chronic diseases such as T2D.

Ethical Considerations

The present research underwent an independent evaluation and obtained an institutional registration number R-2024-1408-004 by the Local Health Research Committee 1408 and from the Research Ethics Committee 1408-8 of the Mexican Social Security Institute.

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Author Contributions

B. O. G.; F. V. H.; E. V. A.: Study design, supervision of data collection, data analysis, manuscript writing.

M. G. S. M.; L. R. G. C.: Supervision of data collection, data analysis, and manuscript writing.

J. A. T. C.; E. L. G. F.: Data analysis, manuscript review.

E. A. M. R.; R. D. S. M.: Supervision of data collection, data analysis, and manuscript review.

B. O. G.; E. V. A.: Data analysis, manuscript review.

F. V. H.; M. G. S. M.: Study design, results validation, manuscript review.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Basto-Abreu, A.C., López-Olmedo, N., Rojas-Martínez, R., Aguilar-Salinas, C.A., De la Cruz-Góngora, V.V., Rivera-Dommarco, J., *et al.* (2021) Prevalence of Diabetes and Glycemic Control in Mexico: National Results from 2018 and 2020. *Salud Pública de México*, **63**, 725-733. https://doi.org/10.21149/12842

[2] (2025) Mujeres y Hombres. https://beta.cuentame.inegi.org.mx/explora/poblacion/mujeres_y_hombres/

[3] Heredia-Pi, I.B., Orozco-Núñez, E., Guerrero-López, C.M., Cerecer-Ortiz, N., Ojeda-Arroyo, E., Allen-Leigh, B., *et al.* (2025) Gendered Experience of People Living with Type 2 Diabetes in Rural and Urban Mexico: An Ethnographic Study. *International Journal for Equity in Health*, **24**, Article No. 157. https://doi.org/10.1186/s12939-025-02523-1

[4] Maguey, H. (2023) Diabetes, la otra gran pandemia del siglo XXI. *Gaceta UNAM*. https://www.gaceta.unam.mx/en-mexico-mas-de-45-de-adultos-padecen-insomnio/

[5] (2025) Bienestar i de s para el. gob.mx. Día Mundial del Sueño 18 de marzo. http://www.gob.mx/insabi/es/articulos/dia-mundial-del-sueno-18-de-marzo?idiom=es

[6] Salud S de. gob.mx (2025) 114. Obesidad, sobrepeso e hipertensión, factores de riesgo para desarrollar apnea del sueño. http://www.gob.mx/salud/prensa/114-obesidad-sobrepeso-e-hipertension-factores-de-riesgo-para-desarrollar-apnea-del-sueno

[7] Borquez, P. (2011) Calidad de sueño, somnolencia diurna y salud autopercibida en estu-diantes universitarios. *Eureka* (*Asunción*) *en Línea*, **8**, 80-90.

[8] Federación Internacional de Diabetes (2025) Datos y cifras. https://idf.org/es/about-diabetes/diabetes-facts-figures/

[9] (2025) EAP_Diabetes2021.docx. https://www.inegi.org.mx/contenidos/saladeprensa/aproposito/2021/

[10] (2025) Analysis of the Risk of Diabetes Mellitus Type 2 in Women Workers at a Reference Hospital in Asuncion, Paraguay. https://www.medicinaclinicaysocial.org/index.php/MCS/article/view/368

[11] Rodríguez-Pérez, C., Carreño-Ruíz, S.D., Ortiz Ojeda, R.F. and Avalos Lázaro, A.A. (2023) Análisis de la relación entre el índice de masa corporal y la somnolencia diurna en universitarios mexicanos. *Revista Española de Nutrición Humana y Dietética*, **27**, 205-212. https://doi.org/10.14306/renhyd.27.3.1918

[12] Clínica Somn (2025) El papel del perímetro abdominal en la apnea del sueño. https://somno.cl/el-papel-del-perimetro-abdominal-en-la-apnea-del-sueno/

[13] Record Cornwall, J., González Cañete, N., Velásquez, A., Bartoli, M. and Durán Agüero, S. (2022) Circunferencia de cintura y sueño en universitarios de chile, Panamá y Paraguay: Estudio multicéntrico. *Spanish Journal of Community Nutrition*, **28**, 7.

[14] K, R. and A, M. (2024) The Relationship between Anthropometric Indices of Obesity and Sleep Disturbances in Young Adults. *Cureus*, **16**, e71178. https://doi.org/10.7759/cureus.71178

[15] Plaza Vera, K.J. and Ambulay Briceño, J.P. (2017) Relación entre la calidad de sueño con el grado de obesidad y circunferencia de cintura en comerciantes del Gran Mercado Mayorista de Lima, 2016. *Revista de Investigación Universitaria*, **5**, 25-31. https://doi.org/10.17162/riu.v5i1.856 https://revistas.upeu.edu.pe/index.php/riu/article/view/728

[16] De la Cruz Llanos, J.E., Flores Luna, J.M. and Lagos Mendieta, N.T. (2024) Asociación entre la calidad del sueño y síndrome metabólico en trabajadores de un Programa de Salud de la ciudad de Ayacucho (Perú) 2023. *Nutrición Clínica y Dietética Hospitalaria*, **44**, 323-330. https://doi.org/10.12873/444delacruz

[17] National Institute of Diabetes and Digestive and Kidney Diseases (2025) Risk Factors for Type 2 Diabetes. NIDDK. https://www.niddk.nih.gov/health-information/diabetes/overview/risk-factors-type-2-diabetes

[18] Dimmick, B. and Dania, D. (2015) Reasonable Accommodations for Diabetes management in the Workplace. American Diabetes Association.

[19] Fazeli, P.K., Lee, H. and Steinhauser, M.L. (2019) Aging Is a Powerful Risk Factor for Type 2 Diabetes Mellitus Independent of Body Mass Index. *Gerontology*, **66**, 209-210. https://doi.org/10.1159/000501745

[20] van 't Riet, E., Dekker, J.M., Sun, Q., Nijpels, G., Hu, F.B. and van Dam, R.M. (2010) Role of Adiposity and Lifestyle in the Relationship between Family History of Diabetes and 20-Year Incidence of Type 2 Diabetes in U.S. Women. *Diabetes Care*, **33**, 763-767. https://doi.org/10.2337/dc09-1586

[21] Jiang, C, Cifu, A.S. and Sam, S. (2025) Section 8: Obesity and Weight Management for the Prevention and Treatment of Type 2 Diabetes. *Clinical Diabetes*, **43**, 207-208.

[22] Hackett, R.A., Dal, Z. and Steptoe, A. (2020) The Relationship between Sleep Problems and Cortisol in People with Type 2 Diabetes. *Psychoneuroendocrinology*, **117**, Article 104688. https://doi.org/10.1016/j.psyneuen.2020.104688

[23] Mostafa, S.A., Mena, S.C., Antza, C., Balanos, G., Nirantharakumar, K. and Tahrani, A.A. (2022) Sleep Behaviours and Associated Habits and the Progression of Pre-Diabetes to Type 2 Diabetes Mellitus in Adults: A Systematic Review and Meta-Analysis. *Diabetes and Vascular Disease Research*, **19**, 1-11. https://doi.org/10.1177/14791641221088824

[24] López Alegría, F., Oyanedel Sepúlveda, J.C., Rivera-López, G., López Alegría, F., Oyanedel Sepúlveda, J.C. and Rivera-López, G. (2020) Calidad del sueño según progresión académica en es-tudiantes chilenos de Obstetricia. *MediSur*, **18**, 211-222.

[25] Smith, K.R., Meeks, H., Curtis, D., Brown, B.B., Kole, K. and Kowaleski-Jones, L. (2024) Family History of Type 2 Diabetes and the Risk of Type 2 Diabetes among Young and Middle-Aged Adults. *Chronic Diseases and Translational Medicine*, **11**, 46-56. https://doi.org/10.1002/cdt3.147

[26] Zeini, M., Laurenti, M.C., Egan, A.M., Muthusamy, K., Ramar, A., Vella, E., *et al.* (2024) The Longitudinal Effect of Diabetes-Associated Variation in *TCF7L2* on Islet Function in Humans. *Diabetes*, **73**, 1440-1446. https://doi.org/10.2337/db24-0192

[27] Ríos, E.V., Luna, M.R., Camacho, M.G., Galicia, L., Daza, E.R.V. and Reyes, V.E. (2023) História parental de diabetes: Fator de risco para diabetes em pelo menos uma criança da familia. https://www.medigraphic.com/pdfs/medfam/amf-2023/amf233c.pdf

[28] Zuraikat, F.M., Laferrère, B., Cheng, B., Scaccia, S.E., Cui, Z., Aggarwal, B., *et al.* (2023) Chronic Insufficient Sleep in Women Impairs Insulin Sensitivity Independent of Adiposity Changes: Results of a Randomized Trial. *Diabetes Care*, **47**, 117-125. https://doi.org/10.2337/dc23-1156

[29] Wondmkun, Y.T. (2020) obesity, Insulin Resistance, and Type 2 Diabetes: Associations and Therapeutic Implications. *Diabetes*, *Metabolic Syndrome and Obesity*: *Targets and Therapy*, **13**, 3611-3616. https://doi.org/10.2147/dmso.s275898

[30] ADA (2025) Insulin Resistance and Diabetes. https://diabetes.org/health-wellness/insulin-resistance

[31] Méndez Inapanta, J.A. (2024) Relación del índice de masa corporal y diabetes mellitus tipo 2 en adultos de ibarra 2023-2024. Bachelor Thesis, Universidad Técnica del Norte. https://repositorio.utn.edu.ec/handle/123456789/16372

[32] American Diabetes Association (2025) Obesity Advocacy. https://diabetes.org/advocacy/obesity

[33] Burhans, M.S., Hagman, D.K., Kuzma, J.N., Schmidt, K.A. and Kratz, M. (2019) Contribution of Adipose Tissue Inflammation to the Development of Type 2 Diabetes Mellitus. *Comprehensive Physiology*, **9**, 1-58. https://doi.org/10.1002/j.2040-4603.2019.tb00055.x

[34] Castillo Pérez, E. (2023) Aplicación de la escala de FINDRISC para determinar el riesgo de desarrollar diabetes mellitus 2 en la población de tulyehualco, xochimilco. https://repositorio.xoc.uam.mx/jspui/handle/123456789/40747

[35] Navarrete, V.P.Q. (2024) Alteración del ciclo sueño/vigilia y su asociación con la resistencia a la insulina: Una revisión sistemática. *Revista Científica de Salud BIOSANA*, **4**, 73-86. https://www.researchgate.net/publication/378455888_Alteracion_del_ciclo_suenovigilia_y_su_asociacion_con_la_resistencia_a_la_insulina_una_revision_sistematica

[36] Colina PCR Neura Institute (2023) El déficit de sueño aumenta la resistencia a la insulina y el riesgo de desarrollar diábetes tipo II. https://www.neurainstitute.com/post/el-d%C3%A9ficit-de-sue%C3%B1o-aumenta-la-resistencia-a-la-insulina-y-el-riesgo-dedesarrollar-di%C3%A1betes-tipo-ii

[37] Song (2023) Association of Sleep Quality, Its Change and Sleep Duration with the Risk of Type 2 Diabetes Mellitus: Findings from the English Longitudinal Study of Ageing. Diabetes/Metabolism Research and Reviews, Wiley Online Library.

[38] Lou, P., Chen, P., Zhang, L., Zhang, P., Yu, J., Zhang, N., *et al.* (2012) Relation of

Sleep Quality and Sleep Duration to Type 2 Diabetes: A Population-Based Cross-Sectional Survey. *BMJ Open*, **2**, e000956. https://doi.org/10.1136/bmjopen-2012-000956

[39] National Institute of Diabetes and Digestive and Kidney Diseases (2025) Factores de riesgo para la diabetes tipo 2. NIDDK. https://www.niddk.nih.gov/health-information/informacion-de-la-salud/diabetes/informacion-general/factores-riesgo-tipo-2

[40] Ortega, G. and del Pilar, M. (2025) Frecuencia de obesidad y su relación con factores de riesgo para diabetes mellitus tipo 2 en usuarios de 18 a 29 años de una unidad de primer nivel de atención. febrero de 2024. https://repositorioinstitucional.uaslp.mx/xmlui/handle/i/8543

[41] Fu, L., Baranova, A., Cao, H. and Zhang, F. (2025) Gut Microbiome Links Obesity to Type 2 Diabetes: Insights from Mendelian Randomization. *BMC Microbiology*, **25**, Article No. 253. https://doi.org/10.1186/s12866-025-03968-8

[42] Diabetologia (2025) Obesity Is a Critical Risk Factor for Type 2 Diabetes, Regardless of Genetics. https://diabetologia-journal.org/2020/04/16/obesity-is-a-critical-risk-factor-for-type-2-diabetes-regardless-of-genetics/

[43] Wainberg, M., Mahajan, A., Kundaje, A., McCarthy, M.I., Ingelsson, E., Sinnott-Armstrong, N., *et al.* (2019) Homogeneity in the Association of Body Mass Index with Type 2 Diabetes across the UK Biobank: A Mendelian Randomization Study. *PLOS Medicine*, **16**, e1002982. https://doi.org/10.1371/journal.pmed.1002982

[44] Lee, H., Choi, J., Kim, N.Y., Kim, J., Moon, M.K., Lee, S., *et al.* (2023) Earlier Age at Type 2 Diabetes Diagnosis Is Associated with Increased Genetic Risk of Cardiovascular Disease. *Diabetes Care*, **46**, 1085-1090. https://doi.org/10.2337/dc22-2144

[45] Cole, J.B. and Florez, J.C. (2020) Genetics of Diabetes Mellitus and Diabetes Complications. *Nature Reviews Nephrology*, **16**, 377-390. https://doi.org/10.1038/s41581-020-0278-5

[46] Tramunt, B., Smati, S., Grandgeorge, N., Lenfant, F., Arnal, J., Montagner, A., *et al.* (2020) Sex Differences in Metabolic Regulation and Diabetes Susceptibility. *Diabetologia*, **63**, 453-461. https://doi.org/10.1007/s00125-019-05040-3

[47] Admin (2022) Las diferencias de sexo son importantes en obesidad y diabetes. *Gaceta UNAM.* https://www.gaceta.unam.mx/las-diferencias-de-sexo-son-importantes-en-obesidad-y-diabetes/

[48] Ou, Y., Lee, J., Huang, S., Chen, S., Geng, J. and Su, C. (2023) Association between Menopause, Postmenopausal Hormone Therapy and Metabolic Syndrome. *Journal of Clinical Medicine*, **12**, Article 4435. https://doi.org/10.3390/jcm12134435

[49] Song, Y., Chang, Z., Song, C., Cui, K., Yuan, S., Qiao, Z., *et al.* (2023) Association of Sleep Quality, Its Change and Sleep Duration with the Risk of Type 2 Diabetes Mellitus: Findings from the English Longitudinal Study of Ageing. *Diabetes/Metabolism Research and Reviews*, **39**, e3669. https://doi.org/10.1002/dmrr.3669

[50] Tourkmani, A.M., Alharbi, T.J., Bin Rsheed, A.M., Alotaibi, A.F., AlEisaa, M., Youzghadli, I.M., *et al.* (2024) Characteristics and Risk Factors Associated with Developing Prediabetes in Saudi Arabia. *Annals of Medicine*, **56**, Article 2413922. https://doi.org/10.1080/07853890.2024.2413922