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CASE STUDY

Associations Between Sleep Quality and Metabolic Syndrome in a Brazilian Population: A Primary and Cross-Sectional Study

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ABSTRACT
Poor sleep quality can affect cardiovascular health and is considered a significant risk factor for the development of risk factors for Metabolic syndrome (MetS). This study aimed to investigate possible associations between sleep quality measured by the Pittsburgh Sleep Quality Index and the MetS. This was a cross-sectional that comprised data from 208 patients. Biochemical and anthropometric parameters were assessed. The identification of MetS was performed according to the International Diabetes Federation guidelines. The quantitative variables were described with the support of the BioEstat 5.3 software. To assess the association of the studied variables with the diagnosis of MetS, the Mann-Whitney and Chi-square (n x n) statistical tests were used. The level of significance considered was 5%. According to the International Diabetes Federation criteria, 111 (53,36%) men and women presented MetS. There were no statically significant differences between the groups with or without sleep disorders and the values of waist circumference (p=0.6996), high-density lipoprotein cholesterol levels (p=0.7940), triglycerides levels (p=0.8703), blood pressure values (p= 0.9851, and p=0.9795 for systolic and diastolic blood pressure, respectively), and glycemia (p=0.5351). Eighty-eight volunteers (42%) presented sleep quality dysfunction, with the highest proportion observed among individuals affected by MetS (p=0.0019). Our results indicate an association between sleep quality and the prevalence of MetS . Therefore, sleep quality could be evaluated in patients with MetS so that the therapeutic strategy would not be limited to the intervention in biochemical and anthropometric factors.

Keywords: Metabolic syndrome; sleep quality; hypertension; dyslipidemia; obesity; diabetes

INTRODUCTION

Modernity has brought many benefits and facilities to human life, but it was also accompanied by lifestyle changes such as reducing physical exercise and changing eating habits, contributing to the increase in the prevalence of cardiovascular diseases (CVD) and other metabolic disorders. The prevalence of sleep disorders has also increased, and many studies have found relationships between CVD, metabolic disorders, and sleep quality [1-4].

Metabolic syndrome (MetS) corresponds to a cluster of different cardiometabolic risk factors that predisposes the affected individuals to increased morbidity and mortality. This condition includes hypertension, hyperglycemia (insulin resistance, IR) or diabetes, elevated triglycerides (TG) and decreased high-density lipoprotein cholesterol (HDL-c), and abdominal obesity. According to the International Diabetes Federation (IDF) guidelines, for the diagnosis of MetS, central obesity and any two of the above four additional cardiometabolic risk factors must be identified [3,5,6].

Adequate sleep is one of the essential pillars of good health, especially mental. Poor sleep or suboptimal sleep quality is considered a sleep disorder and can profoundly affect cardiovascular health.It is considered a major risk factor for the development of hypertension and diabetes [7,8]. Insofar as the elevated blood pressure and the state of IR are deemed cardinal to the development of MetS, there are probably a strong relationship and a massive association between sleep quality parameters and the development of MetS [9,10].

In the Brazilian population, the prevalence of MetS has been increasing consistently since the beginning of this century. In many studies, the overall prevalence of this cardiometabolic disease reaches up to 50% in some areas of the country. The last Brazilian national survey about sleep disorders happened in the year 2008. At that time, the overall prevalence of sleep disorder complaints among the general Brazilian population affected approximately 79.2 million people similarly across the country's regions [11,12].

Many studies have elucidated the role of physical, biochemical, and nutrition abnormalities in losing sleep quality. Obesity and high-calorie intake were associated with reduced sleep performance, increased awakenings, and delayed and decreased rapid eye movement (REM) phase sleep. Hypertension is also a physical abnormality that has already been involved in losing sleep quality, especially when compared with healthy blood pressure controls. Dyslipidemia has also been involved in obstructive sleep apnea during some studies, although without significant clinical relevance yet. Concerning diabetes, the associations are also more intertwined: sleep quality can affect glycemic control, and glycemic control can also decrease sleep quality [13-17].

Considering the high prevalence of MetS and the high prevalence of sleep disturbances in the Brazilian population, this study aimed to identify associations between MetS and sleep disorders and the strength of these associations in a population of the Midwest portion of the Brazilian's São Paulo state. To our knowledge, this is the first study to evaluate MetS associations with sleep quality in the patients of Midwest São Paulo diagnosed with this condition.

MATERIALS AND METHODS

Study design

This was a cross-sectional, observational, analytical, descriptive, single-center study that comprised data from the medical records of 208 patients who attended the Cardiology Unit of the University Hospital Association (ABHU) of the University of Marília (UNIMAR, Marília, São Paulo, Brazil) from July 2021 to October 2021. The included patients were attended for routine cardiovascular consultations or active cardiovascular symptoms.

Study population

The volunteers were adults and elderly of both sexes, aged between 20 or older. Only the patients with the necessary data to conduct this research were included in this final analysis. The maximum interval between the performance of physical examination to collect the required anthropometric parameters and the collection of biochemical tests was three months for all the patients included. Medical records of pregnant and lactating women were excluded, as well as the records of children, adolescents, and recent post-bariatric patients (<2 years).

Data were collected by anonymization. The individual who collected the data was trained to handle the medical records and was not part of the research.

Anthropometric and biochemical analyses

The following anthropometric parameters were investigated: body weight, height, and waist circumference (WC). The anthropometrical and blood pressure assessments were taken by professionals of the Medical and Nutrition schools of the University of Marília as preconized by Lohman et al [18],Gibson et al [19]and Porto et al [20].

Biochemical analyses were performed based on the São Francisco Laboratory protocols at the University of Marília.

Definition of MetS diagnosis

The diagnosis of MetS was performed according to the IDF criteria. The condition was defined when an individual possessed central obesity plus at least two of the following four additional factors cardiometabolic abnormalities: Fasting Blood Glycemia (FBG) ≥ 100mg/dL (or previously diagnosed type 2 diabetes mellitus), blood pressure ≥ 130/85mmHg (or treatment of previously diagnosed hypertension), TG ≥ 150mg/dL (or previous treatment for this metabolic alteration), HDL-cholesterol < 40mg/dL for men and <50mg/dL for women. Central obesity was defined as ≥ 102 cm for males and ≥ 88 cm for females or as a body mass index (BMI) of > 30 kg/m^2 [21].

BMI was calculated according to weight in kilograms divided by height squared (m). The resulting values were referenced according to the World Health Organization (WHO) cut-off points as underweight (<18.5 kg/m^2), average weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2, and obese (≥30 kg/m^2) [22].

Assessment of sleep quality

To investigate the sleep quality of the included subjects, we used the Pittsburgh Sleep Quality Index (PSQI) elaborated by Buysse et al [23], which was translated and valeted to Brazilian-Portuguese by Bertolazi et al [24]. This questionnaire is used as a routine clinical assessment in the Cardiology Unit, where this research was conducted. The PSQI is composed of self-reported questions divided into seven different domains that investigate how the sleep quality of the individuals in the last month was. These domains are 1) sleep quality properly, 2) sleep latency, 3) sleep duration, 4) habitual sleep efficiency, 5) sleep disturbances, 6) sleep medication use, and 7) daytime sleepiness and daytime disturbances. Each domain is scaled from 0 to 3, where zero indicates no problem and three indicates a severe problem. The sum of these values generates an overall score from 0 to 21 in which values ≥5 represent poor sleep quality.

Ethical approval and consent to participate

The Ethics Committee approved all protocols of this study of the University of Marília under the ethical approval number 4.937.991. The researchers respected the Resolutions 466/2012 and 510/2016 of the Brazilian National Health Council and only initiated the study after participants signed up for a free, and informed consent form. Considering that all biochemical and anthropometric parameters used were collected from medical records, it is known that no patient was at risk. However, all study procedures followed the Institutional Ethics Committee and the Helsinki Declaration of 1975 ethical standards (revised in 2013).

Statistical analyses

The quantitative variables were described with the support of the BioEstat 5.3 software for Windows. Data were presented in frequency or average tables and standard derivation according to the analysis profile's minimum and maximum values of each parameter studied. Mann-Whitney and Chi-square (n x n) statistical tests were used to assess the association of the variables with the diagnosis of MetS. The significance probability considered was 5% ($p \leq 0.05$).

RESULTS

The studied sample included 208 participants aged between 20 and 87 (58.96±9.25). By gender, the medical records were from 113 men (45.67%) and 95 women (54.33%). According to the IDF criteria for MetS diagnosis, 111 (53,36%) men and women from the whole sample were affected by MetS. All variables used to diagnose MetS (BMI, WC, FBG, HDL-c, TG, diastolic blood pressure, and systolic blood pressure) were determined for all individuals by groups of sleep quality (with or without sleep disturbances).

Table 1 characterizes the sample according to sex and education. There was a good distribution between females and males. A high relative frequency of individuals with incomplete elementary school (50.48%) was noted.

Table 1. Characterization of patients according to sex and education.

Variables	Categories	Absolute frequency (n)	Relative frequency (%)
	n= 208		
Sex	Females	95	54.32
	Males	113	45.67
Education	Elementary school incomplete	105	50.48
	Elementary school complete	30	14.42
	Middle school complete	46	22.12
	High school complete	27	12.98

Table 2 shows the mean ages of the included volunteers (58.96±9.25) and the mean BMI values, the mean WC values, and the mean PSQI values. The minimum age was 21 years old, and the maximum age was 87 years old. There were no statistical differences between the patients age and the diagnosis of MetS (p=0.3666). The mean BMI and WC values were statistically different among the individuals affected by MetS (p<0.0001). There were also significant statistical differences between the groups of MetS diagnosis and sleep quality (p=0.0080).

Table 2. Characterization of patients according to age, BMI, anthropometric measurements of interest, and the PSQI global scores.

	Global n= 208	With MetS n= 111	Without MetS n= 97	
Variables	Mean and standard derivation			p-value*
Age [years]	58.96± 9.25	59.48±8.41	58.37±10.13	0.3666
BMI [kg/m²]	29.62±6.13	31.70±5.74	27.23±5.70	<0.0001
WC [cm]	100.4±14.82	107.03±12.45	92.99±3.78	<0.0001
Sleep quality score	5.43±3.90	6.06±3.93	4.71± 3.76	0.0080

*Mann-Whitney. BMI: Body Mass Index; MetS: Metabolic syndrome; WC: waist circumference.

The isolated criteria for the diagnosis of MetS according to the IDF guidelines were evaluated with the sample classified into two groups: with and without sleep disorders (Table 3). By analyzing these data and their respective p-values, it was possible to verify that there were no significant differences between the groups with or without sleep disorders and the values of WC (p=0.6996), HDL-c levels (p=0.7940), TG levels (p=0.8703), blood pressure values (p= 0.9851 and p=0.9795 for systolic and diastolic blood pressures, respectively), and FBG levels (p=0.5351).

Table 3. Comparison of variables used as criteria for the diagnosis of MetS between the groups of patients with and without sleep disorders.

Variables for MetS diagnosis		Global n= 208	With sleep disturbances n= 88	Without sleep disturbances n= 120	p-value*
		Mean and standard derivation			
WC [cm]		100.48±14.82	101.30±15.49	99.88±14.35	0.6996
HDL-c [mg/dL]		46.89±14.87	47.95±17.18	46.12±12.13	0.7940
TG [mg/dL]		154.91±84.07	152.62±73.40	156.59±91.37	0.8703
Blood pressures [mmHg]	Systolic	129.82±16.73	129.51±16.15	130.05±17.21	0.9851
	Diastolic	82.82±10.17	82.48±9.87	83.07±10.42	0.9795
Glycemia [mg/dL]		107.37±30.43	104.87±26.54	109.21±32.98	0.5351

*Mann-Whitney. HDL-c: High-density lipoprotein; MetS: Metabolic syndrome; TG: triglycerides; WC: waist circumference.

Eighty-eight volunteers (42%) of the entire sample had sleep quality dysfunctions, with the highest proportion observed among individuals affected by MetS. These observations indicate a statistically significant association between MetS and sleep disturbances (p=0.0019), as seen in Table 4.

Table 4. Associations between the presence of MetS and sleep quality dysfunctions among the study's participants.

MetS	With sleep disturbances	Without sleep disturbances	Total
+	58 (66%)	53 (44%)	111
-	30 (34%)	67 (56%)	97
Total	88 (100%)	120 (100%)	208
p-value	**0.0019***		

*Qui-square (n x n). MetS: Metabolic syndrome.

Table 5 shows the seven components used to assess and classify sleep quality using the PSQI and the global score of the participants separated between the groups with or without the diagnosis of MetS. The mean global sleep questionnaire score of individuals with MetS was significantly higher (6.06 ± 3.93) when compared to the group without MetS (4.71 ± 3.75), indicating that patients with MetS had worse sleep quality (p=0.0080). The domains subjective sleep quality (p=0.0105), sleep disturbance (p=0.0036), and daytime dysfunction (p=0.001) were the questionnaire components that showed statistical differences between the groups with and without MetS.

Table 5. Representation of the overall sleep quality score and by components of the PSQI among participants according to the presence or absence of MetS.

Components of the PSQI	With MetS (n = 111)	Without MetS (n = 97)	p-valor*
	Mean and standard derivation		
Global score	6.06 ± 3.93	4.71 ± 3.75	0.0080
Sleep quality properly	1.06 ± 0.93	0.71 ± 0.80	0.0105
Sleep latency	1.23 ± 0.89	1.00 ± 0.79	0.0711
Sleep duration	6.47 ± 1.35	6.51± 2.08	0.6042
Habitual sleep efficiency	0.45 ± 0.87	0.46 ± 0.91	0.8698
Sleep disturbances	1.20 ± 0.71	0.88 ± 0.71	0.0036
Sleep medication use	0.55 ± 1.05	0.57 ± 1.14	0.8115
Daytime sleepiness and daytime disturbances	0.99 ± 1.07	0.45 ± 0.75	0.0010

*Mann-Whitney. MetS: Metabolic syndrome.

DISCUSSION

Sleep is a cyclically and transient function of the human organism controlled principally by neurobiological processes. However, cardiometabolic diseases may affect its quality, causing sleep disturbances that diminish quality of life. One of these cardiometabolic conditions is MetS, which involves a cluster of different cardiometabolic risk factors [13,25]. In the global literature, there is a lack of studies regarding the assessments of sleep quality in individuals diagnosed with MetS by the criteria established by the IDF.

Godin et al [26] evaluated the sleep quality, chronotype, and MetS diagnosis components in patients with bipolar disorders during the remission period through a national cohort in France that counted withed 752 patients (ranging from 31 to 51 years old). In this study, the sleep quality was measured by the PSQI, and the results demonstrated that euthymic patients with sleep disturbances presented higher WCs and patients with evening chronotypes had increased levels of TG, as well as a most prominent atherogenic profile of dyslipidemia. According to the IDF criteria, 168 (22.4%) individuals in the sample contained MetS.

In Poland, Kiełbasa et al [27] conducted an observational study with 261 subjects (ranging 56.2±16.6 years old) to evaluate sleep disorders among individuals affected by hypertension and coexisting MetS. In this sample, 160 (61.30%) patients were diagnosed with MetS according to the IDF criteria, and the sleep disorders were characterized mainly by the Athens Insomnia Scale. The results showed that sleep disorders were recognized in 183 patients, being more significant among individuals affected by MetS ($p=0.03$) in values up to 75% of prevalence (120 patients of the 160 primarily diagnosed with MetS). Many factors increased the risk of sleep disorders among hypotensive individuals with coexisting MetS in this study such as male gender, poor financial context, the combination of antihypertensives to treat the elevated blood pressure, and tingling sensations before falling asleep.

Wang et al [28] conducted a cross-sectional study in a Chinese Han population to evaluate whether insomnia can be associated with MetS among Chinese individuals. The sample comprised 8017 individuals (ranging from 18 to 82 years old), of which 2381 had the diagnosis of MetS according to the IDF guidelines. To assess insomnia, the Athens Insomnia Scale was used. The results showed that insomnia was not independently associated with MetS across all individuals. Still, the results demonstrated that insomnia was significantly associated with the presence of MetS in male and middle-aged groups with a confidence interval of 95%, but not in the female, young adults, and elder groups. In the final analyses, this sample presented that insomnia was independently associated with elevated blood pressure,low HDL-c levels, and the severity of the metabolic abnormalities among the included volunteers.

Among the Iranian population, the associations of sleep quality components measured by the PSQI and wake time with MetS diagnosis were assessed by Zohal et al [29]. This cross-sectional study comprised 1079 participants (aged between 40.08±10.33 years), of which 330 diagnosed with MetS according to the National Cholesterol Education Program (NCEP ATP III) guidelines. The results showed that PSQI values were significantly higher among MetS individuals than the healthy ($p= 0.013$). Due to these assessments, sleep disturbances were considered predictors of MetS in this sample. In a logistic regression analysis, sleep disturbances could be regarded as cardinal to the MetS occurrence, principally by associating such a 1.388-fold increased risk of MetS after adjustment for age, BMI values, and gender.

in a cross-sectional study, Lee et al [30] evaluated whether poor sleep quality is associated with MetS among Korean individuals (ranging from 50.8±13.1 years old) . This study comprised data from 301 individuals, of which 106 had the diagnosis of MetS confirmed by the NCEP ATP III criteria. In this population, the quality of sleep was measured by the PSQI. The results showed that poor sleep quality and sleep-related breathing disorders are highly and significantly associated with MetS occurrence. In the poor sleep group, the prevalence of the MetS-related risk factors (abdominal obesity, high FBG levels, high TG levels, and decreased HDL-c levels) was higher than the good sleep group.

Chen et al [31] evaluated the associations between sleep quality and MetS among Taiwanese individuals in a 1-year follow-up study that comprised 1359 participants aged between 74.3±6.0 years. In all, 666 volunteers presented the diagnosis of MetS according to the NCEP ATP III criteria, and the Athens insomnia scale measured the sleep quality. The results showed that poor sleep quality worked as a predictor for MetS in this population with a confidence interval of up to 95%. In turn, Tsou et al [32] measured the impact of insomnia symptoms on risk factors related to MetS among the urban elderly in the northern portion of Taiwan. This cross-sectional study comprised data from 1181 participants aged between 74.4±5.5 years.Four hundred and five volunteers presented the diagnosis of MetS according to the NCEP ATP III criteria. The results demonstrated that difficulty falling asleep was the only insomnia symptom significantly associated with the occurrence of MetS in a confidence interval of up to 95% due to the ability of this difficulty to increase hyperglycemia, abdominal obesity, and hypertriglyceridemia prevalence. Deng et al [33] also researched Taiwanese patients to evaluate whether short sleep duration is associated with increased metabolic burden among healthy volunteers. In this cohort study, data from 162,121 adults aged between 20-80 years were evaluated by self-administered sleep questionnaires and by the incidence of five different MetS components. Short sleep duration significantly increased individuals' risk for developing abdominal obesity, higher FBG levels, higher blood pressure, lower HDL-c levels, and hypertriglyceridemia ($p<0.001$) compared to patients with regular sleep duration. Short sleep quality has also demonstrated a correlation with the occurrence of MetS itself at up to 9% of additional risk ($p<0.001$). Long sleep appeared to decrease the risk for hypertriglyceridemia and MetS itself.

In the United States, Yoo & Franke [34] studied the relationships between sleep habits and the MetS among law enforcement officers. The sample comprised 106 individuals (aged between 42.3±8.4 years), of which 35 had the diagnosis of MetS confirmed by a modified American Heart Association/National Heart Lung and Blood Institute (AHA/NHLBI) criteria for diagnosing MetS. These authors used the PSQI for sleep quality assessment, and the results showed that sleep quality was not significantly associated with MetS but with long sleep durations. However, law enforcement employees with poor sleep quality demonstrated more stress, depression, and burnout symptoms than individuals with good sleep quality. Also in the United States, Jennings et al [35] studied the associations between PSQI values and MetS among 210 individuals (aged between 45.8±6.0), of which 41 presented MetS according to the AHA/NHLBI criteria. The results showed that sleep quality was significantly associated with the occurrence of MetS and its risk factors. Linear regression analysis confirmed that higher PSQI values were significantly associated with elevated WCs, BMIs, body fat percentages, elevated FBG levels, and elevated IR assessed by the Homeostatic Model for IR Assessment (HOMA-IR).

CONCLUSION

Like other studies, our results indicate an association between sleep quality and the prevalence of MetS. Therefore, sleep quality could be evaluated in patients with MetS so that the therapeutic strategy would not be limited to the intervention in biochemical and anthropometric factors. We suggest that further studies be performed in other populations with a greater number of patients so that this association is evidenced.

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