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Impact of Insomnia and Night Sleep of Less Than 7 Hours on Metabolic Syndrome and Its Components: A Cross-Sectional Study in Health-Care Workers

ABSTRACT

Objective: The main objective of this study was to investigate the association between night sleep of less than 7 hours and insomnia with metabolic syndrome and its components in health-care workers.

Methods: This cross-sectional study was performed on 410 health-care workers in an educational hospital. Insomnia (inability to fall asleep, stay asleep, or poor sleep quality) and obstructive sleep apnea were evaluated by the insomnia severity index and the STOP-BANG questionnaire, and average hours of sleep were classified as <7 (short sleep), 7-8 (normal sleep), and ≥9 (long sleep) hours. The metabolic syndrome was determined using the Adult Treatment Panel III standards of the National Cholesterol Education Program. The multivariable logistic regression models were used to examine the relationship between sleep duration and insomnia with metabolic syndrome.

Results: The findings showed that the frequency of metabolic syndrome was significantly higher among health-care workers with insomnia (OR = 2.02; 95% CI 1.32-2.48) and short sleep duration (OR = 1.64; 95% CI 1.33-2.17) compared with those without insomnia and with normal sleep duration after adjusting for confounders. Additionally, workers with insomnia and short sleep duration had significantly higher waist circumference levels, systolic blood pressure, and fasting blood glucose levels than those without insomnia and normal sleep duration ($P < .05$).

Conclusion: The current investigation showed night sleep of <7 hours and insomnia in shift workers increase the risk of developing metabolic syndrome. Therefore, paying attention to sleep hygiene, periodic screening for insomnia, and access to physical activity can prevent the occurrence or exacerbation of metabolic syndrome.

Keywords: Health-care workers, insomnia, metabolic syndrome, sleep, sleep duration

Introduction

Metabolic syndrome (MetS), which consists of a complex of metabolic abnormalities (abdominal obesity, high blood pressure, high blood glucose, high serum triglycerides, and low serum high-density lipoprotein),[1] is a significant health problem around the world and is closely associated with the increased risk of diabetes, cardiovascular disease, and all-cause mortality.[2-4] Several occupational and environmental factors, including shift work, low physical activity, too much sitting time, and sedentary jobs, are potential risk factors for MetS.[5,6] According to recent research, disruption of circadian rhythm in health-care workers can cause inadequate sleep,[7] and insufficient sleep is a potential factor for increased MetS and obesity.[8] Multiple epidemiological investigations have identified a U-shaped relationship between sleep duration and MetS.[9,10] The findings of a systematic review showed that individuals who slept for 7 or more hours a night had a lower chance of developing MetS than those who slept for fewer than 6.5 hours.[11] In the study, Liang et al showed that individuals with short sleep durations (night sleep less than 6 hours) had a high prevalence of MetS and some components (central obesity, high blood glucose, high serum triglycerides, and low serum high-density lipoprotein).[12] In contrast, Peila et al showed that sleep duration (≥9 hours) in postmenopausal women (ages 50-79 years) was linked to MetS, increased waist circumference, and high triglyceride levels.[13]

To our knowledge, most studies in this field have concentrated more on sleep duration, and studies exploring the relationships between insomnia and MetS are scarce and inconsistent. In Wang et al's study in Chinese, a statistically significant association was reported between insomnia and MetS and some components [high blood pressure (BP) and low HDL].[14]

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In contrast, a longitudinal study by Troxel et al of 812 Americans aged 45-74 over 3 years showed no notable correlations between the syndromal definition of insomnia and the MetS. However, symptoms of insomnia (difficulty falling asleep and having unrefreshing sleep) were significantly predicted by the development of MetS.[15]

Insomnia (inability to fall asleep or stay asleep or poor sleep quality) is among the most prevalent sleep disorders in approximately 30% of the general population and 23.2% of workers.[16,17] Since inconsistent results exist between it and MetS, the main objective of this study was to investigate the association between night sleep of less than 7 hours and insomnia with MetS and its components in health-care workers.

Material and Methods

This cross-sectional study was conducted on all health-care personnel (n = 443) in an educational hospital in Iran from December 2022 to April 2023. According to study inclusion criteria, study participants must have had shift work and a minimum of 1 year of job experience while enrolled in the study. Before study entrance, each subject provided written informed consent, and the protocol was reviewed and approved by the Ethical Committee of the Iran University of Medical Sciences and Health Services (protocol number: IR.IUMS.FMD.REC.1401.182; approval date: June 27, 2022).

An occupational medicine assistant conducted in-person interviews with the study's participants. The interview began with gathering demographic information, including age, gender, education level, marital status, history of underlying diseases (hypothyroidism, diabetes, hypertension, cardiovascular disease, and malignancy), cigarette smoking, physical activity, and family history of diseases. Furthermore, we excluded health-care workers with a history of psychiatric disorders, chronic renal diseases, cardiovascular disease, stroke, cancer, thyroid diseases, steroid intake, diabetes at baseline, and participants with incomplete information. The interview's second section covered occupational details such as job title, work history, employment status, possession of primary and supplemental insurance, daily and weekly working hours, type of shift working (regular or nonregular), and number of shifts worked in a month.

Sleep Assessment Instrument

The insomnia severity index (ISI) questionnaire was utilized in this study to evaluate insomnia and its symptoms. Insomnia is a sleep disorder characterized by the inability to fall asleep or stay asleep, poor sleep quality, or all 3, despite adequate opportunity for sleep. The ISI questionnaire involves 7 questions assessed on a 5-point Likert-type scale (0-4). This results in a total score that ranges from 0 to 28 and assesses the type and severity of insomnia during the preceding month. When the score is 0-7, there is no clinical insomnia; 8-14, subthreshold insomnia; 15-21, moderate insomnia; and 22-28, severe insomnia.[18] In this study, the no clinical insomnia and subthreshold insomnia groups were classified as having no insomnia, and the moderate and severe insomnia groups were categorized as having insomnia. In addition, participants answered questions on how long they had slept on Saturday through Wednesday and at the end of the week (Thursday and Friday) during the preceding 7 days. Using the formula [(5 × weekday sleep duration) + (2 × weekend sleep duration)/7], the average of weeknights and weekend nights was used to get the average weekly sleep length.[19] Based on reported sleep duration, we divided them into the following groups: <7 hours per night = short sleep; 7-8 hours per night = normal sleep (reference group); and ≥9 hours per night = long sleep.[20] The STOP-BANG questionnaire was utilized to determine the risk of obstructive sleep apnea (OSA). It consists of 8 yes-or-no questions: (i) frequent snoring (S); (ii) daily fatigue (T); (iii) observed apnea (O); (iv) hypertension (P); (v) body mass index (BMI) >35 kg/m^2 (B); (vi) age >50 years old (A); (vii) neck circumference > 40 cm (N); and (viii) male (G). In this study, we divided participants into 2 groups: low-risk (0-2 points) and high-risk (3-8 points), according to their STOP-BANG scores.[21]

Metabolic Syndrome Measurement

The measurement of BP was done while the workers were in a resting position for at least 5 minutes and then repeated 10 minutes later to prevent measurement bias. The mean of 2 measurements was recorded in the study checklist. Anthropometric data such as height, weight, waist circumference, and BMI were obtained for this research. The parameters were measured with the participants not wearing shoes and wearing just the minimum amount of clothing. A stadiometer (SD350) was used to measure participants' heights, and they were instructed to stand straight with relaxed shoulders. The BMI was calculated by dividing weight in kilograms (kg) by height in meters squared (m^2). An elastic tape was placed horizontally between the lateral iliac crest and the lowest rib border to measure the waist circumference accurately. The measures listed above were made twice to lessen the effect of measurement bias.

All participants underwent 12-hour overnight fasting, and blood samples were taken to evaluate fasting blood glucose (FBS, mg/dL) as well as the lipid profile, which includes total cholesterol (TC, mg/dL), triglycerides (TG, mg/dL), low-density lipoprotein (LDL, mg/dL), and high-density lipoprotein (HDL, mg/dL). After blood sampling, FBS and TG levels were measured by the enzyme colorimetric method, and HDL and LDL levels were measured by enzymatic antibodies. In all methods, standard kits (Pars Azmoon) were used.

The presence of MetS was determined using the Adult Treatment Panel III standards of the National Cholesterol Education Program (NCEP ATP III). Participants who met at least 3 of the 5 criteria listed below were considered to have MetS: (1) fasting blood glucose ≥100 mg dL, (2) serum TG ≥150 mg dL, (3) serum HDL <40 mg/dL (men) and <50 mg/dL (women) (4) systolic BP ≥130 mm Hg or diastolic pressure ≥85 mm Hg, (5) waist circumference: >102 cm (men) and >88 cm (women)."[22] Then, the participants were classified into 2 groups: those with MetS and those without MetS.

Statistical Analysis

The statistical tool Statistical Package for the Social Sciences Statistics software for Windows, version 22.0 (IBM Corp., Armonk, NY, USA), was used to enter and evaluate the study data. The normal distribution was assessed using the Kolmogorov–Smirnov goodness test. According to the normal distribution of the study population,

MAIN POINTS

- Health-care workers with insomnia are twice as likely to develop metabolic syndrome compared to workers without insomnia.
- Night sleep of <7 hours in shift workers increases the risk of metabolic syndrome.
- Shift workers with insomnia have higher systolic blood pressure and fasting blood glucose levels.

we used the mean and standard deviation for quantitative data and frequency and percentage for qualitative data. To compare quantitative and qualitative variables between 2 groups of participants, an independent student *t*-test and a chi-square test were used, respectively. The chi-square test was used to compare the frequency of MetS between 2 groups of health-care workers with and without insomnia and between those with normal and short sleep duration. Multivariable logistic regression models were used to investigate the relationships between the frequency of MetS and sleep-related variables (insomnia and sleep duration). In model 1, age and sex; in model 2, age, sex, BMI, smoking status, and work experience; and in model 3, age, sex, BMI, smoking status, work experience, type of shift, and obstructive sleep apnea were adjusted. The multivariable analysis results were displayed as adjusted odds ratios (ORs) and 95% CI. Every statistical test utilized a 2-tailed design with a 0.05 significance threshold.

Results

The present study was conducted on 410 health-care workers with a mean age and work experience of 40.71 ± 1.9 (24-63) and 14.5 ± 1.04 (1-32) years, respectively. Among these participants, 287 (70%) were married, 256 (62.43%) were female, 33 (8.04%) of them were smokers, and more than half of the workers (53.6%) had a bachelor's degree. The mean working hours per day and week were 7.71 ± 1.72 and 53.32 ± 2.15 hours, respectively, and 160 (39.02%) participants had regular shift work.

According to MetS criteria, 211 (51.46%) of the participants had a low serum level of HDL, followed by high blood glucose 169 (41.21%), increased waist circumference 202 (49.26%), an elevated serum level of triglyceride 157 (38.29%), and only 86 had high blood pressure. In the end, 124 individuals (30.24%) met the criteria for the MetS.

Table 1 demonstrates that individuals who had the MetS were considerably more likely to be male (50.8% vs. 31.81%), older (42.64 ± 3.9 vs. 38.86 ± 2.2 years), with a higher BMI (25.12 ± 1.16 vs. 21 ± 2.76 kg/m^2), with higher work experience (14.21 ± 2.42 vs. 11.28 ± 4.67 years), smokers (12.90% vs. 5.94%), nonregular shift workers (69.35% vs. 57.34%), and with OSA (23.38% vs. 14.33%) compared to workers who do not have MetS (Table 1).

The mean insomnia score based on the ISI questionnaire was 11.4 ± 5.7 with a range of 0-24, and 45% of participants had no clinical insomnia, 25% had subthreshold insomnia, 23% had moderate insomnia, and 7% had severe insomnia. The average amount of time spent sleeping on weeknights, weekends, and weekly days was 6.88 ± 1.02, 8.1 ± 1.31, and 7.5 ± 1.9 hours, respectively, and based upon their reported sleep duration, 42.4% of participants were short sleepers (<7 hours per night), 51.5% were normal sleepers (7-8 hours per night), and 6.1% were long sleepers (≥9 hours per night). According to the STOP-BANG score, 340 (82.92%) of workers were at low risk, and 70 (17.07%) were at high risk for OSA.

Association Between Insomnia and Metabolic Syndrome and Its Components

Table 2 shows the associations between insomnia and MetS and the mean differences in MetS components between the 2 groups. Subjects with insomnia had a significantly higher prevalence of MetS (OR = 5.1; 95% CI 3.21-8.07) than those without insomnia ($P < .001$). Also, workers with insomnia had significantly higher levels of waist circumference, systolic blood pressure, and fasting blood glucose than those without insomnia ($P < .05$). The high-density lipoprotein cholesterol level in workers who experienced insomnia was significantly lower than that without insomnia ($P < .05$) (Table 2).

Table 1. Baseline Characteristics of Study Participants According to the Presence or Absence of Metabolic Syndrome

Baseline Characteristics	Yes (n = 124)	No (n = 286)	*P*	OR (95% CI)
Age (years) (mean ± SD)	42.64 ± 3.9	38.86 ± 2.2	<.001	
BMI (kg/m^2) (mean ± SD)	25.12 ± 1.16	21 ± 2.76	<.001	
Male gender n (%)	63 (50.80%)	91 (31.81%)	<.001	2.21 (1.43-3.4)
Marital status (married) n (%)	53 (42.74%)	234 (81.81%)	<.001	0.16 (0.10-0.26)
Cigarette (smoker) n (%)	16 (12.90%)	17 (5.94%)	.020	2.34 (1.14-4.80)
Physical activity (regular) n (%)	51 (41.12%)	207 (72.37%)	<.001	0.26 (0.17-0.41)
Work experience (year) (mean ± SD)	14.21 ± 2.42	11.28 ± 4.67	.01	
Type of shift (nonregular) n (%)	86 (69.35%)	164 (57.34%)	.022	1.68 (1.07-2.63)
OSA (high risk) n (%)	29 (23.38%)	41 (14.33%)	.026	1.82 (1.07-3.10)

BMI, body mass index; OR, odds ratio; OSA, obstructive sleep apnea

Association Between Sleep Duration and Metabolic Syndrome and Its Components

Workers with short sleep duration had a significantly higher prevalence of MetS (OR = 3.1; 95% CI 1.98-4.83) compared to workers with normal sleep duration ($P < .001$). Additionally, compared to workers who slept for a normal duration, workers who slept for a short duration had substantially higher fasting blood glucose, systolic blood pressure, and waist circumference ($P < .05$). Nonetheless, no statistically significant correlation was found between long sleep (more than 9 hours per night) and MetS (Table 3).

In multivariable logistic regression analyses, the prevalence of MetS was significantly higher among workers with insomnia than among those without insomnia after adjusting age and sex (model 1) ($P < .001$; OR = 2.77; 95% CI 2.12-3.98), age, sex, BMI, smoking status, and work experience (model 2) ($P = .004$; OR = 2.23; 95% CI 1.45-3.09), and age, sex, BMI, smoking status, work experience, type of shift, obstructive sleep apnea, and sleep duration (model 3) ($P = .021$; OR = 2.02; 95% CI 1.32-2.48). In addition, the prevalence of MetS was significantly higher among workers with short sleep duration than among those with normal sleep duration after adjusting based on model 1 ($P < 0.001$; OR = 2.37; 95% CI 1.29-2.68), model 2 ($P < .001$; OR = 2.07; 95% CI 1.41-2.38), and model 3 ($P = .034$; OR = 1.64; 95% CI 1.33-2.17) (Table 4).

Discussion

This cross-sectional study among shift workers showed health care workers with insomnia are twice as likely to develop MetS compared

Table 2. Association Between Insomnia and Metabolic Syndrome and Its Components

	No Insomnia (n = 287)	Insomnia (n = 123)	*P*	OR (95% CI)
MetS (%, n)	56 (19.51)	68 (55.28)	<.001	5.1 (3.21-8.07)
	Mean (SD)			
Waist circumference (cm)	71.45 (±3.68)	79.06 (± 2.04)	.001	
Systolic blood pressure (mm Hg)	126.63 (±218)	134.7 (±2.44)	<.001	
Diastolic blood pressure (mm Hg)	77.64 (±1.79)	78.11 (±2.63)	.24	
Fasting blood glucose (mg/dL)	100.21 (±2.09)	112.9 (±3.79)	.02	
Triglycerides (mg/dL)	164.66 (±3.14)	164.01 (±2.13)	.27	
High-density lipoprotein cholesterol (mg/dL)	61.37 (±1.33)	58.07 (± 3.69)	.03	

MetS, metabolic syndrome; OR, odds ratio; SD, standard deviation.

Table 3. Association Between Sleep Duration and Metabolic Syndrome and Its Components

	Normal Sleep (n = 211)	Short Sleep (n = 173)	*P*	OR (95% CI)
MetS (n, %)	45 (21.32)	79 (45.66)	<.001	3.1 (1.98-4.83)
	Mean (SD)			
Waist circumference (cm)	72.55 (± 2.17)	83.11 (± 4.34)	<.001	
Systolic blood pressure (mm Hg)	126.12 (±2.9)	131.89 (±3.76)	<.001	
Diastolic blood pressure (mm Hg)	78.08 (±2.43)	78.23 (±3.5)	.14	
Fasting blood glucose (mg/dL)	103.43 (±1.56	110.9 (±2.6)	.03	
Triglycerides (mg/dL)	157.87 (±2.07	163.65 (±7.85)	.06	
High-density lipoprotein cholesterol (mg/dL)	64.17 (±4.04)	63.59 (± 2.05)	.24	

MetS, metabolic syndrome; OR, odds ratio; SD, standard deviation.

with those without insomnia (OR = 2.02). Also, workers with insomnia had significantly higher levels of waist circumference, systolic blood pressure, fasting blood glucose, and low levels of high-density lipoprotein cholesterol than those without insomnia.

The current study's findings agreed with the meta-analyses conducted by Che et al[23] and Wang et al,[14] who both found significant positive associations between insomnia and MetS. In Wang et al's[14] study in Chinese, a statistically significant relationship was reported between insomnia and MetS and some components like high BP and low HDL. In the longitudinal study by Troxel et al[15] of 812 Americans aged 45-74 over 3 years, there was no statistically significant relationship between the syndromal definition of insomnia and the MetS.

The difference observed between our study and certain other studies appears to be caused by variations in participant age and racial distributions, study methodologies, and criteria and tools used to assess insomnia, so further epidemiological investigation is required to clarify these associations.

In the current study, health-care workers with short sleep duration are one and a half times (OR = 1.64) more likely to develop MetS than those with normal sleep duration (7-8 hours). Similar to our study, a systematic review showed that individuals who slept for fewer than 6.5 hours were more likely to acquire MetS than those who slept for 7 or more hours.[11] Furthermore, compared to people who sleep 7-8 hours, middle-aged adults who sleep fewer than 6 hours are at increased risk for MetS and abdominal obesity, according to research

Table 4. Association Between Insomnia and Sleep Duration with Metabolic Syndrome Based on the Multivariable Logistic Analysis

				Model 1*	Model 2**	Model 3***
		No insomnia (n = 287)	Insomnia (n = 123)	Adjusted OR (95% CI), *P*	Adjusted OR (95% CI), *P*	Adjusted OR (95% CI), *P*
MetS	No (n = 286)	231 (80.48%)	55 (44.71%)	Ref	Ref	Ref
	Yes (n = 124)	56 (19.51%)	68 (55.28%)	2.77 (2.12-3.98), < .001	2.23 (1.45- 3.09), .004	2.02 (1.32- 2.48), 0.021
				Model 1*	Model 2**	Model 3****
		Normal sleep duration (n = 211)	Short sleep duration (n = 173)	Adjusted OR (95% CI), *P*	Adjusted OR (95% CI), *P*	Adjusted OR (95% CI), *P*
MetS	No (n = 260)	166 (78.67%)	94 (54.33%)	Ref	Ref	Ref
	Yes (n = 124)	45 (21.32%)	79 (45.66%)	2.37 (1.29-2.68), <.001	2.07 (1.41-2.38), <.001	1.64 (1.33-2.17), .034

MetS, metabolic syndrome.
*Odds ratio adjusted for age and sex.
**Odds ratio adjusted for age, sex, BMI, smoking status, work experience.
***Odds ratio adjusted for age, sex, BMI, smoking status, work experience, type of shift, obstructive sleep apnea, and sleep duration.
****Odds ratio adjusted for age, sex, BMI, smoking status, work experience, type of shift, obstructive sleep apnea, and insomnia.

by Hall et al.[9] In addition, we observed that workers with short sleep duration had significantly higher levels of waist circumference, systolic blood pressure, fasting blood glucose, and low-level HDL than those with normal sleep duration. In the study, Liang et al showed that individuals with short sleep durations (night sleep less than 6 hours) had a high prevalence of MetS and some components (central obesity, high blood glucose, high serum triglycerides, and low serum high-density lipoprotein).[12]

The mechanism underlying the relationship between MetS and sleep length, quality, and duration is unknown. Based on studies, inadequate sleep is associated with more time to eat, reduced energy consumption, and less physical activity.[24,25] Short sleep duration increases calorie intake, especially carbohydrate-rich nutrients, by 14% in individuals with normal weight[19,26] and by 15% in middle-aged obese individuals.[26]

In addition, glucose tolerance, glucose effectiveness, insulin sensitivity, β cell function,[27,28] and anorexigenic leptin levels[29-31] are reduced following inadequate sleep. Following 3 nights of suppression of deep sleep, there is a 25% reduction in sensitivity to insulin[32] and a 23% decrease in glucose tolerance,[26] and the risk of diabetes and IGT is increased. Short sleep duration through changes in leptin, ghrelin, insulin, and cortisol levels can lead to increased appetite and preference for high-energy foods.[24,25] In this study, there was no significant association between long sleep duration (≥9 hours per night) and MetS and its components. Contrary to our results, Peila et al[13] showed that sleep duration (≥9 hours) in postmenopausal women (ages 50-79 years) was linked to MetS, large waist circumference, and high TG levels. One of the reasons that could explain these differing results is that individuals with long sleep duration were very low in our study, so it is recommended that more extensive sample size studies be conducted to examine the relationship between long sleep duration and the prevalence of MetS.

Our research has several advantages and disadvantages; one of its advantages is that sleep duration and insomnia have been investigated, unlike other studies. There were 3 notable limitations. Firstly, this study was based on cross-sectional data, so we could not determine a causal relationship between insomnia, sleep duration, and MetS. Second, the sleep duration and insomnia information was based on self-reported questions. However, valid questionnaires (such as the ISI) are used primarily to screen for sleep disorders, and objective instruments are not always used. Finally, our study focused on shift workers with higher sleep disturbances than the general population, which can affect the results of our research.

Our study showed that disruption of circadian rhythm caused by shift work can increase the risk of MetS and its components. As in other studies, improper metabolism of glucose and lipids, the role of adipose tissue, and heart-related,[33] vascular, and hemostatic functions[33-35] have been shown in shift workers. Therefore, considering the effect of insomnia and short sleep duration on the frequency of MetS, organizations need to design a well-designed shift system with rotating shift schedules so employees can maintain a work–life balance.

The current investigation showed shift workers with insomnia and short sleep duration are at risk of developing MetS and have higher waist circumference, systolic blood pressure, fasting blood glucose, and low high-density lipoprotein cholesterol levels. Therefore, paying attention to sleep hygiene, changing working hours, and access to physical activity can prevent the occurrence or exacerbation of MetS. Also, it is recommended that shift workers be screened periodically for insomnia to prevent MetS.

Ethics Committee Approval: This study was approved by Ethics Committee of Iran University of Medical Sciences and Health Services (Approval number: IR.IUMS.FMD.REC.1401.182, Date: June 27, 2022).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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