Original Article

Association of sleep quality components and wake time with metabolic syndrome: The Qazvin Metabolic Diseases Study (QMDS), Iran

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ABSTRACT

Purpose: The aim of this study was to determine the association of sleep quality and sleep quantity with metabolic syndrome in Qazvin, Iran.
Methods: this cross sectional study was conducted in 1079 residents of Qazvin selected by multistage cluster random sampling method in 2011. Metabolic syndrome was defined according to the criteria proposed by the national cholesterol education program third Adult treatment panel. Sleep was assessed using the Pittsburgh sleep quality index (PSQI). A logistic regression analysis was used to examine the association of sleep status and metabolic syndrome.
Results: Mean age was 40.08 ± 10.33 years. Of 1079, 578 (52.2%) were female, and 30.6% had metabolic syndrome. The total global PSQI score in the subjects with metabolic syndrome was significantly higher than subjects without metabolic syndrome (6.30 ± 3.20 vs. 5.83 ± 2.76, P = 0.013). In logistic regression analysis, sleep disturbances was associated with 1.388 fold increased risk of metabolic syndrome after adjustment for age, gender, and body mass index.
Conclusion: Sleep disturbances component was a predictor of metabolic syndrome in the present study. More longitudinal studies are necessary to understand the association of sleep quality and its components with metabolic syndrome.

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1. Introduction

Sleep/wake cycle and circadian system have considerable effects on behavioral activities, day/night rhythms, and physiological processes (e.g., endocrine function) which may result in health problems [1]. Human behaviors and habits may suppress the control mechanisms of physiological processes that cause alterations of sleep quality and duration [2].

It has been shown that insufficient sleep duration and sleep fragmentation change sympatho-vagal balance with an increase in sympathetic nervous system activity [3] which inhibits insulin secretion, promotes insulin resistance, and contributes to the development of metabolic syndrome [4]. Sleep pattern especially sleep duration plays an essential role in rhythms of releasing hormones related to the energy homeostasis and weight gain such

as ghrelin, leptin, insulin, cortisol, and growth hormone [5,6]. In addition appropriate sleep/wake cycle decreases serum catecholamine and cortisol concentration [7] that finally prevents metabolic syndrome. Okubo et al. in a cross-sectional study reported that men with poor sleep quality had 2.37 times increased risk of developing metabolic syndrome [8]. Moreover, Hall et al. found that short and long sleep duration (less or more than 7 to 8 h per night) are associated with 45% increased risk of metabolic syndrome [9].

There are evidences that short sleep duration is associated with increased risk of metabolic syndrome components (i.e. obesity, impaired glucose metabolism . . .) but the knowledge on the relevance of sleep quality and metabolic syndrome is not yet enough. Studies on the association of sleep quality and its components with metabolic syndrome are limited in the world and Iran [10–12] and more investigations are needed. Therefore, the aim of this study was to determine the association of sleep quality and sleep quantity with metabolic syndrome in Qazvin, Iran.

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2. Material and Methods

This population based cross-sectional study was performed on a representative sample of residents of Minoodar district of Qazvin- which is located 150 km northwest of Tehran capital of Iran- from September 2010 to April 2011. The study was approved by the ethics committee of Qazvin University of Medical Sciences.

The sampling unit was the household and all households had health profiles at the health center located in the district. The Minoodar district was divided into four main clusters according to the population size. The households were selected by multistage cluster random sampling methods. The inclusion criterion was age ≥20 yr. Subjects were invited by phone call to attend the study and after explanation of the study details, they were free to participate. All subjects gave their written informed consent. A total of 1107 people were entered to the study. Demographic and social data were self-reported in the questionnaire given to the subjects. Two general practitioners filled out an organized questionnaire including medical history and physical examination. Details of sampling method and data collection have been published elsewhere [13].

All anthropometric and laboratory measurements were performed after 12–14 h overnight fasting. Anthropometric indices including waist circumference (WC), weight, height and body mass index (BMI) were measured. WC was measured to the nearest 0.1 cm using a flexible, non-elastic measuring tape midway between the costal margin and the iliac crest at the end of normal expiration. Body mass index (BMI) was calculated as weight (kg) divided by the height (m) squared. Blood pressure (BP) was measured three times on a single occasion by a mercury sphygmomanometer, in a seated position, and after a 15 min rest. Serum levels of glucose, triglycerides (TGs), total cholesterol, high-density lipoprotein cholesterol (HDL) and low-density lipoprotein cholesterol (LDL) were measured for all subjects in the same laboratory. Complete details of the methods have been published previously [13–15].

Metabolic syndrome was defined according to the criteria proposed by the national cholesterol education program third Adult treatment panel [16] when at least three of the following conditions were met: WC ≥ 102 cm in men or ≥ 88 cm in women, serum triglycerides ≥ 150 mg/dl, HDL < 40 mg/dl for men and < 50 mg/dl for women, Fasting plasma glucose ≥ 100 mg/dl (includes diabetes) and systolic blood pressure (SBP) ≥130 mmHg or diastolic blood pressure (DBP) ≥ 85 mmHg.

Sleep quality was assessed using the Pittsburgh sleep quality index (PSQI). The PSQI is a 19-item self-rated questionnaire that evaluates sleep quality over a 1-month time interval and generates seven sleep component scores on a 0–3 scale, with three indicating the worst condition. The sum of scores for these components composes a global PSQI score. The higher the PSQI score, the worse the sleep quality. Poor sleep quality was defined as PSQI score greater than 5 [17].

Sleep duration was assessed with self-reported questions about bedtime and wake time for each subject. Sleep duration was classified into three groups: less than 6 h, between 6 and 8 h and more than 8 h. Wake time was also classified into three groups: earlier than 6.00 am; 6–7 am and after 7:00 am Bedtime after 12:00 amwas considered as late sleep onset.

Data were recorded as mean ± standard deviation (SD) or number (percent). The PSQI components were compared between subjects with and without metabolic syndrome using Mann Whitney *U* test. Chi-square test was used for analysis of categorical variables. A logistic regression analysis was used to examine the association of sleep status and metabolic syndrome. P-values less than 0.05 were considered as statistically significant.

3. Results

A total of 1107 participants (20–72 years old) enrolled in the study. Of these, 1079 had complete questionnaires and laboratory tests. Mean age was 40.08 ± 10.33 years. Of 1079, 578 (52.2%) were female, and 30.6% had metabolic syndrome. Subjects with metabolic syndrome were older than normal subjects (44.58 ± 8.64 vs. 37.26 ± 10.20; P < 0.001). The prevalence of metabolic syndrome was not significantly different between males and females (32.4% vs. 28.7%).

The total global PSQI score was 6.00 ± 2.91. This score was 5.83 ± 2.76 in the subjects without metabolic syndrome and 6.30 ± 3.20 in the subjects with metabolic syndrome. The difference was statistically significant between two groups (P = 0.013). PSQI scores of the study subjects are shown in Table 1. Only sleep duration, sleep disturbances, and use of sleep medication scores were significantly higher in the subjects with metabolic syndrome compared to the subjects without metabolic syndrome.

The relationship between sleep patterns and metabolic syndrome are shown in Table 2. In univariate analysis, wake time was associated with metabolic syndrome while sleep duration and bedtime were not associated with metabolic syndrome. In logistic regression analysis, sleep disturbances was associated with 1.388 fold increased risk of metabolic syndrome after adjustment for age, gender, and body mass index (Table 3).

4. Discussion

Today, living in modern societies with increased daily activities and community duties often leads to transformations in daily living schedule and accordingly many individuals experience a form of circadian misalignment [2]. In several researches, it has been mentioned that the relationship between sleep pattern and metabolic changes may increase the risk of non-communicable diseases, such as obesity, hypertension, and insulin resistance [18,19]. Although sleep quantity has been linked to metabolic

Table 1
PSQI scores of the study subjects.

Component	Total	Subjects with metabolic syndrome	Subjects without metabolic syndrome	Z value	P-value
Subjective sleep quality	0.99 ± 0.64	1.04 ± 0.68	0.97 ± 0.62	1.517	0.129
Sleep latency	1.14 ± 0.93	1.13 ± 0.92	1.14 ± 0.93	0.047	0.962
Sleep duration	0.80 ± 0.76	0.88 ± 0.79	0.77 ± 0.75	2.276	0.023
Habitual sleep efficiency	0.36 ± 0.76	0.37 ± 0.79	0.35 ± 0.75	0.196	0.844
Sleep disturbances	1.14 ± 0.52	1.25 ± 0.57	1.09 ± 0.49	4.587	< 0.001
Use of sleep medication	0.23 ± 0.66	0.33 ± 0.78	0.19 ± 0.59	2.824	0.005
Daytime dysfunction	1.33 ± 0.83	1.35 ± 0.84	1.33 ± 0.82	0.477	0.633
Total PSQI	5.97 ± 2.91	6.30 ± 3.20	5.83 ± 2.76	1.737	0.082

Data are presented as mean ± SD.

Table 2
Relationship between sleep patterns and metabolic syndrome.

Variable		Total *	Subjects with metabolic syndrome	Subjects without metabolic syndrome	χ^2	df	P-value
Sleep quality	well	363	255(70.2)	108(29.8)	0.210	1	0.675
	poor	707	487(68.9)	220(31.1)			
Bedtime	on or before 12.00 a.m.	886	268(30.2)	618(69.8)	0.070	1	0.782
	after 12.00 a.m.	163	51(31.3)	112(68.7)			
Wake time	before 6.00 a.m.	127	48(37.8)	79(62.2)	8.714	2	0.013
	between 6 and 7 a.m.	483	152(31.5)	331(68.5)			
	after 7 a.m.	420	106(25.2)	314(74.8)			
Sleep duration	<6 h	37	15(40.5)	22(59.5)	1.893	2	0.388
	6–8 h	748	226(30.2)	522(69.8)			
	>8 h	267	79(29.6)	188(70.4)			

Data are presented as number (percent).

Table 3
Logistic regression analysis of the relationship between "sleep" and "metabolic syndrome".

Variable		β value	SE	OR[a]	95% CI	P-value
Poor sleep quality		0.015	0.173	1.015	0.724–1.425	0.929
PSQI factors	Subjective sleep quality	0.084	0.157	1.087	0.800–1.478	0.593
	Sleep latency	−0.087	0.105	0.916	0.747–1.125	0.403
	Sleep duration	0.215	0.127	1.240	0.966–1.591	0.092
	Habitual sleep efficiency	−0.129	0.129	0.879	0.683–1.132	0.318
	Sleep disturbances	0.328	0.173	1.388	0.990–1.947	0.057
	Use of sleep medication	0.144	0.130	1.155	0.895–1.492	0.269
	Daytime dysfunction	−0.091	0.107	0.913	0.740–1.126	0.394
Late sleep onset		0.279	0.234	1.322	0.836–2.089	0.232
Wake time	6–7 a.m.			1		
	<6 a.m.	0.223	0.247	1.250	0.771–2.028	0.366
	>7 a.m.	0.056	0.187	1.058	0.733–1.527	0.764
Sleep duration	6–8 h			1		
	<6 h	0.060	0.456	1.062	0.427–2.643	0.897
	>8 h	0.073	0.194	1.076	0.736–1.573	0.706

[a] Adjusted for age, gender, and body mass index.

syndrome in previous studies [20,21], the association of sleep quality and metabolic syndrome is not well understood.

In the present study, the global PSQI score in subjects with metabolic syndrome was higher than those without metabolic syndrome. Okubo et al. [8] in a cross-sectional study among 1481 Japanese general population have reported the same results. Hung et al. [22] have also confirmed the association between global PSQI score and metabolic syndrome. Araújo et al. in a study among university students found that students with poor sleep quality had five percent increased risk of developing metabolic syndrome [23]. On the other hand, Kazman et al. [24] and Hall et al. [12] did not find any significant association between global PSQI scores and metabolic syndrome.

Global PSQI score alone is insufficient to determine sleep status and PSQI components should also be considered. However, most researchers have focused only on the PSQI scores for the evaluation of sleep status and there has been limited attention to the sleep quality components. In the present study, the association of PSQI score as well as its components with metabolic syndrome was examined. In univariate analysis, short sleep duration, sleep disturbances, and use of sleep medication in addition to poor sleep quality were associated with metabolic syndrome. However, only the association of sleep disturbances and metabolic syndrome was confirmed in multivariate analysis. In Okubo et al. study [8] among Japanese population, the global PSQI score, sleep latency score, and sleep disturbance score of subjects with metabolic syndrome were higher than other subjects. In another study by Chang et al. [25], police officers with higher scores of sleep disturbances had a higher prevalence of metabolic syndrome but the association was not confirmed in regression analysis.

In the present study, the sleep disturbances component was associated with 1.388 fold greater risk of metabolic syndrome after controlling the effects of age, gender, and body mass index. In support of our findings, Okubo et al. found similar results for the sleep disturbances component [8]. Currently the exact mechanism underlying the association sleep and risk of metabolic syndrome is not fully understood. But this result may be explained by the fact that activated Hypothalamic-pituitary- adrenal axis affects sleep pattern [26].

In the present study, univariate analysis showed that waking earlier than 7:00 amwas associated with metabolic syndrome compared to waking later than 7:00 am However, this association was not confirmed in multivariate analysis. Ghorbani et al. in a cross-sectional study among 982 subjects reported that earlier wake time was associated with worse glucose metabolism [15]. In contrast, Nakanishi-Minami et al. in a study on 106 Japanese outpatients with lifestyle-related diseases found that subjects with type 2 diabetes mellitus slept later and woke up later than subjects without type 2 diabetes mellitus [27]. One possible explanation for these results is that the circadian system is linked to various processes that control both sleep and metabolism and sleep-wake cycle and fasting-feeding behavior may affect the circadian clock [28].

The main strength of the present study is that the association of both sleep quality and its components with metabolic syndrome was investigated. On the other hand, the subjects with metabolic syndrome completed the sleep questionnaire before they knew the results of the evaluation and the diagnosis of metabolic syndrome had no effect on their perceived quality of sleep. The present study had some limitations including its cross-sectional design and the number of studied subjects. Sleep quality was assessed only

subjectively and obstructive sleep apnea and sleep disorders were not evaluated.

In conclusion, sleep duration, sleep disturbances, and use of sleep medication components and early wake-up time were associated with metabolic syndrome in the present study. Attending to sleep hygiene principles and regulating the sleep/ wake pattern can affect the risk of metabolic syndrome. Only sleep disturbances component was a predictor of metabolic syndrome in the present study. However, more longitudinal studies are necessary to understand the association of sleep quality and its components with metabolic syndrome.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Authors' contributions

All authors participated in planning the study, data collection, data analyses and writing.

Ethical approval

The study was approved by Regional Ethical Qazvin University of Medical Sciences (code: 28/20/11141).

Informed consent

Our research involved human participants who had obtained informed consent.

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