

*Original Article***Association between sleep duration and metabolic syndrome in a population-based study: Isfahan Healthy Heart Program**

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**Abstract**

**BACKGROUND:** Recent epidemiologic studies have found that self-reported sleep duration is associated with components of metabolic syndrome (MS) such as obesity, diabetes and hypertension. This relation may be under influence of regional factors in different regions of the world. The association of sleep duration and MS in a sample of Iranian people in the central region of Iran was investigated in this study.

**METHODS:** This cross-sectional study was conducted as a part of the Isfahan Healthy Heart Program (IHHP). A total of 12492 individuals aged over 19 years, 6110 men and 6382 women entered the study. Definition of National Cholesterol Education Program was used to define MS. Sleep duration was reported by participants. Relation between sleep duration with MS was examined using categorical logistic regression in two models; unadjusted and adjusted for age and sex.

**RESULTS:** In our study, 23.5 % of participants had MS. Compared with sleep duration of 7-8 hours per night; sleep duration of less than 5 hours was associated with a higher odds ratio for MS. This association remained significant even after adjustment for age and sex (OR: 1.52; 95%CI: 1.33-1.74). However, sleep duration of 9 hours or more showed a protective association with MS (OR: 0.79; 95%CI: 0.68-0.94).

**CONCLUSIONS:** There was a positive relation between sleep deprivation and MS and its components. This relation was slightly affected by sex and age.

**KEYWORDS:** Sleep, Metabolic Syndrome, Heart, Population.

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**M**etabolic syndrome (MS) consists of a constellation of metabolic abnormalities that presents increased risk of cardiovascular disease (CVD).<sup>1</sup> The criteria for the MS have evolved since the original definition by the World Health Organization in 1998, reflecting growing clinical evidence and analysis by a variety of consensus conferences and professional organizations.<sup>2</sup> The major features of the MS include central obesity, hypertriglyceridemia, low HDL cholesterol, hyperglycemia, and hypertension. According to Adult Treatment Panel (ATP III), three of these

criteria characterize MS.<sup>3</sup>

The prevalence of obesity and type 2 diabetes is increasing worldwide. The causes of this pandemic are not fully explained by changes in traditional lifestyle factors such as diet and physical activity.<sup>4</sup> Concurrent with these rises, there has been a similar epidemic of chronic sleep deprivation.<sup>5</sup> According to the study of Sarrafzadegan et al, age-adjusted prevalence of MS in the central region of Iran was 23.3%. The prevalence was higher among women and urban individuals.<sup>6</sup>

Recent epidemiologic studies have found

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that self-reported habitual sleep duration is associated with obesity, diabetes, hypertension, and higher mortality.<sup>7-21</sup> Both cross-sectional and prospective epidemiologic studies have linked sleep durations of 6 hours or less per night with increased prevalence and incidence of hypertension.<sup>5, 16</sup> Moreover, it has been shown that mid life adults who are short sleepers are at increased risk for CVD.<sup>19-22</sup>

Studies on the association between sleep and health are relatively new in Iran. This study aimed to assess the association of MS components with sleep duration in a sample of Iranian men and women.

## Methods

### Study population

This cross-sectional study was conducted as a part of the Isfahan Healthy Heart Program (IHHP). IHHP was a six year comprehensive integrated community based program for CVD prevention and control via reducing CVD risk factors and improvement of cardiovascular healthy behaviors.<sup>23</sup>

Participants were 12514 individuals aged over 19 years, that 12492 of them (6110 men and 6382 women) had lipid profile measurements. After signing informed written consent, sociodemographic characteristics such as age, sex, marital status, occupation, education and income were recorded. Sleep time was obtained by the question "how many hours of sleep do you usually get?".<sup>23</sup> This study was approved in Research Council of Isfahan Cardiovascular Research Center.

Height, weight, waist circumference (WC) and blood pressure were measured by trained health professionals. Weight was measured with calibrated scale in the standing position and with light cloths. Height was measured in the standing position with the subject bare-foot.<sup>24</sup> Body mass index (BMI) was calculated as weight/height<sup>2</sup> (kg/m<sup>2</sup>). Waist circumference was measured at the part of the trunk located midway between the lower costal margin (bottom of lower rib) and the iliac crest (top of pelvic bone) while the person was standing, with feet about 25-30 cm apart.<sup>24</sup> Blood pres-

sure was measured twice on the right arm, in sitting position and after 15 minutes rest. The mean of two recordings was reported. The first and 5<sup>th</sup> Korotkoff sounds were considered as systolic and diastolic blood pressure, respectively.<sup>25</sup>

Metabolic syndrome were defined as subjects who had three or more of the following criteria as defined by the National Cholesterol Education Program:<sup>26</sup> (1) Central obesity as the waist circumference > 102 cm in men and > 88 cm in women; (2) Fasting plasma triglycerides  $\geq$  150 mg/dl; (3) low HDL cholesterol with fasting HDL cholesterol < 40 mg/dl in men and < 50 mg/dl in women; (4) hypertension with systolic blood pressure  $\geq$  130 mmHg and/or diastolic blood pressure  $\geq$  85 mmHg and/or antihypertensive agents (5) hyperglycemia with fasting plasma glucose  $\geq$  100 mg/dl and/or hypoglycemic medications.

Data was recorded and analyzed using SPSS for Windows (version 15.0; SPSS Inc., Chicago, IL, USA). Chi-square and ANOVA test were used to compare qualitative and quantitative data, respectively. The relation between sleep duration with MS was examined using multinomial logistic regression in two models, in the first model adjusted by age separated in sex group. In the second one, the model was adjusted by sex based on age groups.

## Results

The study population included 49.9% men and 51.1% women with a mean age of  $38.89 \pm 14.93$  years. In our study, 23.5 % of participants had MS. Of all participants, 61% reported sleeping 7-8 hours per night, 11.6% reported sleeping 5 hours or less and 8.7% reported sleeping 9 hours or more. Subjects with lower sleep duration were older and had a higher BMI and WC ( $P < 0.01$ ) (Table 1).

Compared with sleep duration of 7-8 hours per night, sleep duration < 5 hours was associated with a higher odds ratio for MS. This association remained significant even after adjustment for age and sex. However, sleep duration of 9 hours or more showed a protective effect on MS (Table 2).

**Table 1.** Characteristic of the study participants

	Reported usual sleep time per night				Total	P
	≤ 5	6	7-8	≥ 9		
Number of subjects (%)	1447(11.6)	2336(18.7)	7622(61)	1087(8.7)	12492	-
Age (year) <sup>1</sup>	47.35(16.19)	40.52(14.36)	37.26(14.08)	35.49(15.81)	38.89(14.93)	<0.01
Female sex (%) <sup>2</sup>	50.1	47.5	51.1	60	51.1	<0.01
Body mass index (kg/m <sup>2</sup> ) <sup>1</sup>	26.21(5.12)	26(4.68)	25.32(4.68)	25.02(5.08)	25.52(4.78)	<0.01
Metabolic syndrome components						
High blood pressure <sup>2</sup>	38.4	27.1	24.5	21.5		<0.01
High triglyceride <sup>2</sup>	54.4	49.4	45.4	41.3	46.8	<0.01
Low HDL <sup>2</sup>	43.3	44.2	45.6	48	45.3	>0.05
High fasting blood sugar <sup>2</sup>	12.1	6.4	6.3	7.4	7.1	<0.01
High waist circumference <sup>2</sup>	46.2	39.4	35.7	34.3	37.5	<0.01
Number of metabolic syndrome component(s) <sup>2</sup>						
0	14.1	18.1	19.5	20.1	18.7	
1	26.5	31.1	32	35.1	31.4	<0.01
2	25.9	26.2	26.8	24.3	26.3	
≥3	33.5	24.6	21.7	20.5	23.5	
Metabolic syndrome <sup>2</sup>						
With	33.5	24.6	21.7	20.5	23.5	<0.01
Without	66.5	75.4	78.3	79.5	76.5	

<sup>1</sup> indicates ANAOVA test (mean (SD)).

<sup>2</sup> indicates chi-square test (%).

HDL, High density lipoprotein;

After adjustment for age, odds ratio of MS in females increased in sleep duration less than 5 hours and decreased in sleep duration over 9 hour (model 1, Table 3). After adjustment for sex, odds ratio of MS in people under 60 years increased in sleep duration less than 5 hours and decreased in sleep duration over 9 hours (model 2, Table 3).

## Discussion

In this study we found association between MS and sleep duration in women aged less than 60

years with sleep duration below 5 hours. Sleep duration over 9 hours showed a protective effect on MS in women over 60 years.

Our findings are different from similar studies in other countries. Hall et al<sup>27</sup> reported that after adjustment for use of antihypertensive medication, prevalence of MS and its components remained high in short sleepers of American people. Only short sleep duration was correlated to MS, while sex was not a significant factor. In a sample of Korean people, Choi<sup>28</sup> found that both short and long sleep

**Table 2.** Odds ratio of metabolic syndrome in different usual sleep time per night categories

Usual sleep time per night	Model	
	1*	2**
	Metabolic Syndrome	Metabolic Syndrome
≤5	1.81(1.60,2.05)	1.52(1.33,1.74)
6	1.17(1.05,1.31)	1.20(1.07,1.35)
≥9	0.93(0.79,1.09)	0.79(0.68,0.94)

Data are given as odds ratio (95%confidence interval) for the presence of metabolic syndrome, form multinomial logistic regression models using 7-8 hours of sleep per night as the reference category.

\* model 1 was Unadjusted

\*\* Model 2 was adjusted for age and, sex.

**Table 3.** Odds ratio of metabolic syndrome in different usual sleep per night categories based on sex and age group

Reported usual sleep time per night					
Variable		Number of subject	≤5	6	≥9
Model 1	Sex				
	Male	5976	1.25(0.99,1.57)	1.08(0.89,1.32)	0.77(0.55,1.09)
	Female	6320	1.69(1.43,2.00)	1.26(1.09,1.46)	0.81(0.67,0.98)
Model 2	Age (year)				
	<60	10699	1.70(1.46,1.99)	1.23(1.08,1.39)	0.84(0.70,1.007)
	≥60	1597	1.09(0.84,1.41)	1.06(0.79,1.41)	0.61(0.40,0.92)

Data are given as odds ratio (95 % confidence interval) for the presence of metabolic syndrome, base on sex & age group form multinomial logistic regression models using 7-8 hours of sleep per night as the reference category.

Model 1: adjusted by age

Model 2: adjusted by sex

durations are related to increased risk of the MS and its components. In the Korean population more components of the MS were highly associated with sleep duration in subjects less than 60 years old compared to those over 60. Altogether, these studies suggest that sleep duration may be an important risk factor for the MS. There is no explanation for the differences in the effect of sex and age on interaction of sleep duration and MS between our study and other similar studies. It may be related to genetic ethnicity or differences in daily life stresses.

In healthy subjects, experimental sleep restriction causes insulin resistance and increases evening cortisol and sympathetic activation.<sup>29</sup> In the general population, obstructive sleep apnea is associated with glucose intolerance.<sup>29</sup> Possible pathways linking short sleep duration to hypertension and cardiovascular events include increases in body weight and changes in glucose metabolism. Nedeltcheva et al<sup>30</sup> tested the hypothesis that the curtailment of human sleep could promote excessive energy intake. In this study sleep restriction was accompanied by increased consumption of calories from snacks, with higher carbohydrate content, particularly during the period from 19:00 to 07:00. Therefore, recurrent bedtime restriction can modify the amount, composition, and distribution of human food intake. In another study a single night of sleep deprivation increased ghrelin levels and feelings of hunger in nine normal-weight healthy men.<sup>31</sup>

Sleep deprivation is associated with a dysregulation of the neuroendocrine control of appetite, with a reduction of the satiety factor, leptin, and an increase in the hunger-promoting hormone, ghrelin. Thus, sleep loss may alter the ability of leptin and ghrelin to accurately signal caloric need, acting in concert to produce an internal misperception of insufficient energy availability.<sup>32</sup> In one study, the effects of sleep duration on leptin were quantitatively associated with alterations of the cortisol and TSH profiles and were accompanied by an elevation of post breakfast homeostasis model assessment values.<sup>5</sup>

These studies suggest a relationship between sleep restriction, weight gain and diabetes. This risk may involve at least three pathways: alterations in glucose metabolism, upregulation of appetite and decreased energy expenditure.<sup>33</sup>

Most of these studies have shown association between short sleep duration and components of MS, however, there is little evidence on the relation between long sleep duration and MS components. Long sleep duration might be a compensation for or a reaction to stressful living conditions. If this is right, then more sleep hours may act as a coping strategy, alleviating some adverse effects of stresses on health. It may also act simply as a protective factor, saving individual from stressful hours. We did not differentiate between short or long sleep duration and disordered sleep or sleep apnea.

## Conclusion

There is a relation between sleep duration and MS and its components. This relation is affected slightly by sex and age. However, this cross-sectional study could not deduce a causal relation between sleep duration and MS. Further studies are needed to clarify whether sleep duration can be considered as a cardiovascular risk factor. As the incidence of sleep deprivation is increasing, it would be an essential health problem in the future.

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## Conflict of Interests

Authors have no conflict of interests.

## Authors' Contributions

JN carried out the design and prepared the manuscript. NM coordinated the study design and participated in data collection and prepared the manuscript. NT provided assistance in design and manuscript preparation. All authors have read and approved the content of the manuscript.

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