Alpha Psychiatry

ORIGINAL ARTICLE
Alpha Psychiatry 2024;25(6):705-712
DOI: 10.5152/alphapsychiatry.2024.241565

Associations Between Delayed Sleep Phase Syndrome and Daytime Napping with the Metabolic Syndrome Among Adults: Results from the Ravansar Non-Communicable Disease (RaNCD) Cohort Study

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Received: February 25, 2024
Revision Requested: April 23, 2024
Last Revision Received: July 19, 2024
Accepted: July 22, 2024
Publication Date: December 15, 2024

Cite this article as: Hemati N, Alipourian A, Moradinazar M, et al. Associations between delayed sleep phase syndrome and daytime napping with the metabolic syndrome among adults; results from the Ravansar non-communicable disease (RaNCD) cohort study. *Alpha Psychiatry.* 2024;25(6):705-712.

ABSTRACT

Objective: Adverse sleep and wake patterns are associated with physical health complaints, including metabolic disorders. The aim of this study was to evaluate the relationship between delayed sleep phase syndrome (DSPS) and napping during the day with metabolic syndrome (MetS).

Methods: This study was conducted on 10 065 participants aged 35-65 years using baseline data from the Ravansar Non-Communicable Disease (RaNCD) cohort study. Delayed sleep phase syndrome was evaluated through a clinical interview to rule out the possibility that the sleep complaints were a result of psychiatric disorders. Logistic and linear regression models were used to determine associations.

Results: The severity of MetS was found to be higher in men, older age groups, married people, subjects with a lower education level, urban residents, smokers, people with low physical activity, and DSPS. In the fully adjusted model, the odds of having MetS were 26% (95% Confidence interval (CI): 1.08, 1.48) higher in those with DSPS compared to those without DSPS. Additionally, the odds of MetS were 18% higher in people who napped less than 1 hour per day, 26% higher in those who napped 1-2 hours per day, and 21% higher in those who napped over 2 hours per day, compared to non-nappers. All of these associations were statistically significant. The odds of having the severity of MetS were significantly 6% (95% CI: 0.01, 0.12) higher in those with DSPS compared to those without DSPS.

Conclusion: The findings of this study indicate that DSPS and daytime napping are associated with an increased risk of MetS. Interventions aimed at improving sleep quality are recommended as potential strategies to help reduce the risk of developing MetS.

Keywords: Delayed sleep phase syndrome, metabolic syndrome, physical inactivity, Ravansar non-communicable disease cohort study

Introduction

Metabolic syndrome (MetS) has become a global epidemic and a global problem.[1] Key features of this complex syndrome is a cluster of interconnected factors including abdominal obesity, elevation of arterial blood pressure (hypertension), dysregulated blood homeostasis, hyperlipidemia (dyslipidemia) in blood analyses, and insulin resistance.[2] More specifically, in the Middle East, MetS-related risks were 15.9% for cardiovascular diseases, 11.7% for coronary heart diseases, and 16.2% for stroke.[3] In general, as regards the prevalence rates among adults in the Middle East (Türkiye, Saudi Arabia, Pakistan, Qatar, Kuwait, Emirates, Iran, and Yemen), rates range between 2.2% (Türkiye) and 63% (Pakistan), with higher intercountry variability and with an average prevalence of 25%.[3] Further, as regards the prevalence rates of MetS in Iran, the overall prevalence rate was 30.4%, with higher prevalence rates among females (34.8%) compared to males and with higher prevalence rates with increasing age:

the prevalence rate was 12.1% for those aged 20-29; the prevalence rate was 51.7% among those aged 60 years and older.[4]

The main drivers of metabolic syndrome seem to be a high-calorie, low-fiber diet and decreased physical activity due to reliance on mechanical transportation. To address the incidence of metabolic syndrome, interventions should aim to modify these lifestyle factors through a low-calorie, high-fiber diet and increased regular physical activity like walking and cycling.[1]

For the following three reasons, the emergence of metabolic syndrome was associated with sleep disorders,[5-8] and delayed sleep phase syndrome (DSPS) demands particular attention.[9,10] Delayed sleep phase syndrome is the most common circadian rhythm sleep–wake phase irregularity, compared to advanced sleep phase syndrome (ASPS), and while DSPS typically emerges in adolescence, adults also report DSPS. Additionally, DSPS leads to shortened sleep durations. In particular, naturally occurring and experimentally induced shortened sleep durations were causally associated with the risk of impaired cognitive,[11] emotional,[12-14] behavioral[15-19] and social and interactional performance.[20] Given this, DSPS and the related shortened sleep duration could be considered a risk factor for further health issues.

While the lack of regular physical activity and the excess of unhealthy energy intake were traditionally identified as risk factors for MetS and obesity, these two factors were unable to fully explain the high prevalence of MetS.[8] As such, both insufficient sleep and circadian misalignment were considered further independent and additional drivers for the emergence and maintenance of MetS. Indeed, poor sleep, in general, and circadian misalignment, more specifically, have been identified to causally trigger obesity,[21,22] insulin resistance,[23] and higher scores for MetS,[5,6,24] such that Zimmet et al[25] proposed labeling the co-occurrence of circadian misalignment and MetS as "circadian syndrome". Among 4579 adults aged 60 years and older, Qian et al.[24] observed a J-shaped association, with very short and very long nocturnal sleep durations being associated with higher scores for MetS, while a sleep duration of about 7 hours was associated with lower scores for MetS, at least among males compared to females.[24]

Previous studies have looked at the links between sleep and MetS, but no one has really dug into the relationship between DSPS and MetS in Iran. Therefore, this study evaluates the association between DSPS and MetS among a large group of Kurdish adults living in western Iran.

MAIN POINTS

- *The prevalence of metabolic syndrome (MetS) was 33.53% in the study population.*
- *Delayed sleep phase syndrome (DSPS) was significantly more prevalent in people with MetS compared to those without MetS (62.1% vs. 37.9%).*
- *The severity of MetS was found to be higher in men, older age groups, married people, those with lower education levels, urban residents, smokers, people with low physical activity, those suffering from DSPS, and participants who took longer daytime naps.*
- *The odds of having MetS were 26% higher in those with DSPS compared to those without DSPS. Additionally, the odds of having more severe MetS were 6% higher in those with DSPS compared to those without DSPS.*

Material and Methods

Study Population

This cross-sectional study is the baseline phase of the Ravansar Non-Communicable Disease (RaNCD) cohort study conducted in Kermanshah, Iran. The RaNCD cohort study is part of the PERSIAN (Prospective Epidemiological Research Studies in Iran) cohort study established in March 2015. Pasdar et al.[26] reported the protocol in detail. Both the Digestive Disease Research Institute (DDRI) and the Ministry of Health and Medical Education of Iran (https://irancohorts.ir/prospective-epidemiological-research-studies-in-iran/) approved the study, which has been conducted in accordance with the seventh an current[27] edition of the Declaration of Helsinki.

As extensively described elsewhere,[26] the RaNCD cohort was established in 2015, when 10 065 adults aged 35-65 years who were permanent residents of urban or rural areas of Ravansar were willing to participate in the study. They had good health status and were able to communicate. Further, the RaNCD study was the first cohort study to investigate non-communicable diseases (NCDs) in a Kurdish population.

Measures

We collected information via clinical interviews, self-rating questionnaires, and lab analyses (see details below).

Sociodemographic Information: All interviews and all measurements for all participants were assessed in cohorts run by well-trained and experienced staff members. Participants completed sociodemographic questionnaires within 45-60 minutes.

Lifestyle Factors

Tobacco Smoking: A smoker was defined as someone who had smoked at least 100 cigarettes in his or her lifetime.

Sleep Patterns: Delayed sleep phase syndrome was assessed based on a thorough clinical interview for psychiatric disorders[28] to rule out sleep complaints as a result of psychiatric disorders and based on a thorough clinical interview for sleep disorders.[29] To this end, we performed a clinical interview to more specifically ask participants for circadian rhythm sleep–wake disorders (chapter 4 of the International Classification of Sleep Disorders).[29] Further, participants completed the Farsi version[30] of the Composite Scale of Morningness (CSM)[31] to assess diurnal preferences.

1. Advanced sleep phase syndrome is characterized by a stable sleep schedule that is several hours earlier (onset of sleep from 06:00 PM to 09:00 PM, and morning wake time from 02:00 AM to 05:00 AM) than the conventional or desired time.
2. Delayed sleep phase syndrome is characterized by a stable sleep schedule that is substantially later than the conventional or desired time; that is to say, the onset of sleep is 2 or more hours later than 11:00 PM to 01:00 AM early in the morning, and morning wake time is from 09:00 AM to 11:00 AM. These time frames are based on previous definitions. Typically, DSPS is observed when going to bed and starting to sleep are delayed for 2 or more hours compared to the socially acceptable and usual bedtime for people of the same age.[9,10]

Physical Activity Patterns; Metabolic Equivalent of Task: The level of physical activity was calculated using metabolic equivalent (MET) rates based on the self-reported daily activities of the RaNCD participants.[32] One MET equals the amount of oxygen/energy consumed in 1 minute when quiet (resting metabolic rate), which is approximately 3.5 mL/kg/min. Following the example, 4 METs require 16 mL/kg/min of energy,[33] and we calculated the METs for each activity using a compendium of physical activities.[34] The mean MET rates of the cohort participants were calculated (i.e., 41 METs/h/day), and participants with less than the mean MET rate were considered to have an insufficient level of physical activity.

Anthropometric Information: Weight, height, blood pressure, and the waist-to-hip-ratio were objectively assessed as a proxy for central obesity. To define central obesity, the following cut-off values were employed: For females: Waist-to-hip ratio (WHR) ≥ 0.85; for males: WHR ≥ 0.90. A bio-impedance analyzer (BIA) (InBody 770 BIOSPACE, Seoul, Korea) and a stadiometer were employed to objectively measure weight (kg) and height (in cm, with 0.1 cm accuracy). A manual sphygmomanometer was employed to measure blood pressure.

Metabolic Syndrome: To define MetS, we followed the National Cholesterol Education Program (NCEP), Adult Treatment Panel III (ATP III);[35] MetS is identified, when three or more of the following criteria are met: central obesity, high fasting glucose, high serum triglyceride, high serum high-density lipoprotein (HDL) cholesterol, and high blood pressure. Further, to calculate MetS severity, we followed Lee et al[36] (http://mets.health-outcomes-policy.ufl.edu/calculator/).

Statistical Analysis

Mean and SD (standard deviation) of parametric continuous variables and median with the interquartile range (Q1-Q3) values were reported for nonparametric continuous variables, and frequency distribution of categorical ones was described using descriptive statistics. Testing for statistical significance of difference was performed using the independent *t*-test and 1-way ANOVA test for continuous variables and the chi-square test for categorical variables. We also utilized the Wilcoxon rank-sum test, a non-parametric statistical method employed to assess whether there is a significant difference between the medians of two independent groups. Cliff's delta is used as a non-parametric effect size measure that quantifies the difference between two groups of observations beyond chance. The measure ranges from −1 to 1, where 0 indicates stochastic equality and 1 indicates that the first group completely dominates the second group. To calculate Cliff's delta values for more than two groups, the effect size is first computed for each pair of groups. Then, a weighted mean of the Cliff's delta values across all these pairwise comparisons is calculated to provide an overall measure of the effect size.

We evaluated the distribution of circadian rhythm sleep disorders in the population and how they varied by the incidence of MetS and MetS severity. Additionally, a series of multiple logistic and linear regression analyses were performed to calculate the associations between the circadian rhythm sleep disorders with MetS and MetS severity, while adjusting for age, sex, education categories, employment status, smoking consumption, BMI (Body Mass Index) categories, and regular exercise. The statistical level of significance was $P < .05$. All statistical calculations were performed with SPSS v21.0 (Statistical Package for the Social Sciences [SPSS] Manufacturer: IBM Corporation Headquarters: Armonk, New York, United States).

Results

Sociodemographic and Health-Related Indices Between Participants with and Without Metabolic Syndrome

Table 1 provides the sociodemographic and health-related descriptive and statistical indices, separated between participants with MetS (n = 3367 (33.53%)) and without MetS (n = 6698 (66.47%)). Compared to individuals without MetS, those with MetS were more likely to be female, older, have a lower level of education, and engage in less physical activity (less than 41 MET-hours per week). Individuals with MetS also had a higher prevalence of DSPS and longer daytime napping periods. Additionally, the presence of MetS was associated with higher diastolic blood pressure, systolic blood pressure, fasting blood glucose, triglyceride levels, and a larger waist circumference.

Associations Between Metabolic Syndrome Severity Score and Sociodemographic and Health-Related Dimensions

The median Metabolic Syndrome Severity Score (MSSS) was found to be higher in men compared to women. The median MSSS exhibits a positive association with increasing age, implying that older individuals tend to present with higher severity scores. Conversely, the median MSSS demonstrates an inverse relationship with elevated daytime naps and educational levels, indicating that higher degrees of educational attainment and daytime nap attainment are linked to lower severity scores. Additionally, the severity of metabolic syndrome was higher in people with low physical activity, those suffering from DSPS, and participants who took longer daytime naps (Table 2).

Delayed Sleep Phase Syndrome, Daytime Napping and Further Sociodemographic Information to Predict the Occurrence of Metabolic Syndrome (MetS)

In the crude model, the odds of having MetS were significantly 26% (95% CI [confidence interval]: 1.08, 1.48) higher in those with DSPS compared to those without DSPS. The odds of MetS were 18% (OR [odds ratio] = 1.18, 95% CI: 1.06, 1.33) higher in people who napped for less than 1 hour per day, 24% (OR = 1.24, 95% CI: 1.11, 1.38) higher in those who napped 1-2 hours per day and 21% (OR = 1.21, 95% CI: 1.05, 1.39) higher in those who napped more than 2 hours per day, compared to people who did not nap during the day (for all $P < .05$). This association also remained significant after adjusting for potential confounding factors. In the fully adjusted model, the odds of having MetS were significantly 23% (95% CI: 1.06, 1.42) higher in those with DSPS compared to those without DSPS. The odds of MetS were 19% (OR = 1.19, 95% CI: 1.07, 1.34) higher in people who napped for less than 1 hour per day, 27% (OR = 1.27, 95% CI: 1.15, 1.42) higher in those who napped 1-2 hours per day, and 29% (OR = 1.29, 95% CI: 1.13, 1.49) higher in those who napped more than 2 hours per day, compared to people who did not nap during the day (for all $P < .05$) (Table 3).

Delayed Sleep Phase Syndrome, Daytime Napping, and Further Sociodemographic Information to Predict the Metabolic Syndrome Severity Score

In the crude model, the risk of having MSSS was significantly 5% (95% CI: −0.01, 0.11) higher in those with DSPS compared to those without DSPS. The odds of MetS were 8% ($\beta = 0.08$, 95% CI: 0.03, 0.12) higher in people who napped for less than 1 hour per day, 24% ($\beta = 0.11$, 95% CI: 0.07, 0.15) higher in those who napped 1-2 hours per day, and

Table 1. Sociodemographic and Anthropometric Characteristics of Participants in the Ravansar Non-Communicable Disease Cohort Study by Metabolic Syndrome

			Metabolic Syndrome, N (%)		
Variables	**Subgroups**	**N (%)**	**No**	**Yes**	***P***
Total population		10041 (100)	6674 (66.47)	3367 (33.53)	–
Gender	Male	4761 (47.42)	3416 (71.75)	1345 (28.25)	<.001[a]
	female	5280 (52.58)	3258 (61.71)	2022 (38.29)	
Age groups (year)	35-44	4323 (43.05)	3276 (75.78)	1047 (24.22)	<.001[a]
	45-54	3355 (33.41)	2124 (63.31)	1231 (36.69)	
	55-65	2357 (23.47)	1270 (53.88)	1087 (46.12)	
Marital status	Single/divorced/widow	981 (9.77)	671 (68.40)	310 (31.60)	.177[a]
	Married	9054 (90.17)	5999 (66.26)	3055 (33.74)	
Education level	Illiterate	2474 (24.64)	1425 (57.60)	1049 (42.40)	<.001[a]
	1-5 years	3840 (38.24)	2524 (65.73)	1316 (34.27)	
	6-9 years	1674 (16.67)	1189 (71.03)	485 (28.97)	
	10 and more years	2047 (20.39)	1532 (74.84)	515 (25.16)	
Residence area	Urban	5988 (59.64)	3890 (64.96)	2098 (35.04)	<.001[a]
	Rural	4047 (40.3)	2780 (68.69)	1267 (31.31)	
Smoking	Yes	2014 (20.06)	1365 (67.78)	649 (32.22)	.161[a]
	No	8006 (79.73)	5294 (66.13)	2712 (33.87)	
Low physical activity (MET <41)	Yes	6421 (63.95)	4040 (62.92)	2381 (37.08)	<.001[a]
	No	3614 (35.99)	2630 (72.77)	984 (27.23)	
Delayed sleep phase syndrome	No	9191 (91.53)	6146 (66.9)	3045 (33.1)	.005[a]
	Yes	844 (8.41)	524 (62.1)	320 (37.9)	
Daytime nap	No	3696 (36.81)	2572 (69.59)	1124 (30.41)	<.001[a]
	Less than 1 hour	2385 (23.75)	1565 (65.62)	820 (34.38)	
	1 to 2 hours	2698 (26.87)	1732 (64.20)	966 (35.80)	
	2 hours and more	1256 (12.51)	801 (63.77)	455 (36.23)	
Diastolic Blood Pressure, mmHg, Mean ± SD		10026 (100)	141.54 (1.41)	73.39 (11.01)	<.001[b]
Systolic Blood Pressure, mmHg, Mean ± SD		10026 (100)	220 (2.19)	115.24 (19.28)	<.001[b]
Fasting Blood Glucose, mg/dL, Mean ± SD		10026 (100)	200.05 (1.99)	109.12 (38.93)	<.001[b]
High Density Lipoprotein, mg/dL, Mean ± SD		10026 (100)	90.25 (0.9)	41.13 (9.21)	<.001[b]
Triglyceride, mg/dL, Mean ± SD		10026 (100)	301.7 (3)	191.24 (101.79)	<.001[b]
Waist Circumference, cm, Mean ± SD		10041 (100)	196.92 (1.96)	102.09 (8.83)	<.001[b]

[a]Results from the chi square test.
[b]Results from the independent sample *t* test.
MET, Metabolic Equivalent; SD, Standard Deviation.

13% ($\beta = 0.13$, 95% CI: 0.07, 0.18) higher in those who napped more than 2 hours per day, compared to people who did not nap during the day (for all $P < .05$).

In the fully adjusted model, the odds of having MSSS were significantly 6% (95% CI: 0.01, 0.12) higher in those with DSPS compared to those without DSPS. The odds of MetS were 6% ($\beta = 0.06$, 95% CI: 0.01, 0.10) higher in people who napped for less than 1 hour per day, 8% ($\beta = 0.08$, 95% CI: 0.04, 0.12) higher in those who napped 1-2 hours per day, and 9% ($\beta = 0.09$, 95% CI: 0.03, 0.14) higher in those who napped more than 2 hours per day, compared to people who did not nap during the day (Table 4).

Discussion

We investigated among 10 065 adults aged 35 to 65 years the associations between MetS and specific sleep phase syndromes, including daytime napping. The key findings were that MetS was highly associated with the occurrence of DSPS, along with the occurrence and the duration of daytime napping. This pattern remained robust, even when controlling for sociodemographic factors such as age, sex, marital status, residence area, education level, smoking status, and physical activity. The present results add to the current literature in four ways. First, while previous studies investigated single possible confounders (see below), we integrated a broad variety of possible confounders in the same statistical model, which allowed a more accurate and broad description of sociopsychological and sociodemographic factors possibly associated with both MetS and DSPS. Second, we tested the statistical models among a large sample of adults. Third, we introduced daytime napping as a further possible and independent factor. Given this background, we claim that the present data are of practical and clinical importance in that adults with DSPS and daytime napping were at a statistically increased risk to suffer from MetS. Fourth, we provide an accurate picture of health issues related to MetS and sleep patterns, including daytime naps, among a larger sample of Iranian adults aged 35 to 65 years.

As shown in Table 1, the first pattern of results showed that the occurrence of MetS was associated with a broad variety of physiological

Table 2. Metabolic Syndrome Severity Score Across the Subgroups of Participants in the Ravansar Non Communicable Disease Cohort Study

Variable	Subgroup	N (%)	Cliff's Delta Values	Metabolic Syndrome Severity Score Median (p50)	p25	p75	P[a]
Gender	Male	4761 (47.42)	0.051	0.19	−0.31	0.69	<.001
	Female	5280 (52.58)		0.06	−0.45	0.62	
Age groups (years)	35-44	4323 (43.05)	−0.27	-0.02	−0.50	0.50	<.001
	45-54	3355 (33.41)		0.23	−0.28	0.76	
	55-65	2357 (23.47)		0.29	−0.26	0.83	
Marital status	Single/divorced/widow	981 (9.77)	−0.18	-0.06	−0.06	0.052	<.001
	Married	9054 (90.17)		0.14	−0.36	0.67	
Education level	Illiterate	2474 (24.64)	0.15	0.16	−0.35	0.73	<.001
	1-5 years	3840 (38.24)		0.11	−0.40	0.66	
	6-9 years	1674 (16.67)		0.09	−0.39	0.64	
	10 and more years	2047 (20.39)		0.10	−0.39	0.60	
Residence area	Urban	5988 (59.64)	0.15	0.17	−0.33	0.69	<.001
	Rural	4047 (40.3)		0.05	−0.46	0.60	
Smoking	Yes	2014 (20.06)		0.10	−0.41	0.63	<.001
	No	8006 (79.73)		021	−0.29	0.74	
Low physical activity (MET < 41)	Yes	6421 (63.95)	0.12	0.02	−0.33	0.71	<.001
	No	3614 (35.99)		0.02	−0.48	0.55	
Delayed sleep phase syndrome	No	9191 (91.53)	0.026	0.12	−0.39	0.66	<.001
	Yes	844 (8.41)		0.17	−0.35	0.72	
Daytime nap	No	3696 (36.81)	−0.11	0.06	−0.42	0.58	<.001
	Less than 1 hour	2385 (23.75)		0.16	−0.36	0.67	
	1 to 2 hours	2698 (26.87)		0.18	−0.31	0.76	
	2 hours and more	1256 (12.51)		0.22	−0.37	0.80	

[a]Results from Wilcoxon rank-sum test.

(high diastolic and systolic blood pressure, higher fasting glucose and triglycerides, greater waist circumference), behavioral (low physical activity levels), and above all, sleep-related factors. Among the sleep-related factors, a DSPS, along with longer daytime napping, was the most critical deteriorating factor. Further, female gender, older age, lower education and living in rural areas were identified as sociodemographic factors.

Table 2 reports the predictors of MetS severity. Almost identical factors were identified for MetS severity as already observed for MetS occurrence, that is to say: female gender, higher age, lower education, modest physical activity levels, and, importantly, DSPS and daytime napping predicted higher MetS scores. For physical activity, MetS was associated with higher physical inactivity; as such, the present data confirmed previous results.[37,38]

For daytime napping, the occurrence of DSPS and daytime napping were unique predictors of MetS and MetS severity, above and beyond sociodemographic and physiological variables (Tables 3 and 4). The present result expanded upon the current literature, as we showed the prominent factors of DSPS and daytime napping in predicting higher scores for MetS and MetS severity. Importantly, daytime napping

Table 3. Association Between Delayed Sleep Phase Syndrome and Daytime Nap with Metabolic Syndrome by Logistic Regression Models

IDF Metabolic Syndrome	Model 1 OR (95% CI)	P	Model 2 OR (95% CI)	P	Model 3 OR (95% CI)	P	Model 4[a,b] OR (95% CI)	P
Delayed Sleep Phase Syndrome								
No	1		1		1		1[a]	
Yes	1.23 (1.06, 1.42)	.005	1.34 (1.15, 1.56)	<.001	1.30 (1.11, 1.51)	.001	1.26 (1.08, 1.48)	.003
Daytime Nap								
No	1		1		1		1[b]	
Less than 1 hour	1.19 (1.07, 1.34)	.001	1.21 (1.08,1.35)	.001	1.20 (1.07, 1.34)	.002	1.18 (1.06, 1.33)	.004
1 to 2 hours	1.27 (1.15, 1.42)	<.001	1.27 (1.14, 1.41)	<.001	1.28 (1.15, 1.42)	<.001	1.24 (1.11, 1.38)	<.001
2 hours and more	1.29 (1.13, 1.49)	<.001	1.25 (1.09, 1.44)	.001	1.27 (1.10, 1.46)	.001	1.21 (1.05, 1.39)	.009
models' P	<.001		<.001		<.001		<.001	

Model 1: Crude model.
Model 2: Adjusted for age and sex.
Model 3: Adjusted for age, sex, marital status, residence area, and education level.
Model 4[a]: Adjusted for age, sex, marital status, residence area, education level, smoking status, physical activity, and daytime nap.
Model 4[b]: Adjusted for age, sex, marital status, residence area, education level, smoking status, physical activity, and delayed sleep phase syndrome.
IDF, International Diabetes Federation; OR, Odds Ratio; CI, Confidence Interval.

Table 4. Association between Delayed Sleep Phase Syndrome and Daytime Nap with Metabolic Syndrome Severity Score by Linear Regression Models

Metabolic Syndrome Severity	Model 1 β (95% CI)	P	Model 2 β (95% CI)	P	Model 3 β (95% CI)	P	Model 4[a,b] β (95% CI)	P
Delayed sleep phase syndrome								
No	1		1		1		1[a]	
Yes	0.05 (−0.01, 0.11)	.085	0.10 (0.04, 0.15)	.001	0.08 (0.02,0.14)	.009	0.06 (0.01, 0.12)	.046
Daytime Nap								
No	1		1		1		1[b]	
Less than 1 hour	0.08 (0.03, 0.12)	<.001	0.07 (0.02, 0.11)	.002	0.06 (0.02, 0.10)	.005	0.06 (0.01, 0.10)	.010
1 to 2 hours	0.11 (0.07, 0.15)	<.001	0.09 (0.05, 0.13)	<.001	0.09 (0.05, 0.14)	<.001	0.08 (0.04, 0.12)	<.001
2 hours and more	0.13 (0.07, 0.18)	<.001	0.10 (0.05, 0.16)	<.001	0.11 (0.06, 0.16)	<.001	0.09 (0.03, 0.14)	.002
Models' *P*	<.001		<.001		<.001		<.001	

Model 1: Crude model.
Model 2: Adjusted for age and sex.
Model 3: Adjusted for age, sex, marital status, residence area, and education level.
Model 4[a]: Adjusted for age, sex, marital status, residence area, education level, smoking status, physical activity, and day-time nap.
Model 4[b]: Adjusted for age, sex, marital status, residence area, education level, smoking status, physical activity, and delayed sleep phase syndrome.

increased the odds of reporting both DSPS and MetS. However, given the cross-sectional nature of the study, it remains unclear if daytime napping was the consequence or the trigger of higher DSPS and MetS levels. Poor night sleep was associated with more daytime sleepiness[39-42] and with a higher propensity for day napping. In contrast, daytime napping reduced sleep need in the evening and delayed bedtime. As such, a bidirectional and vicious cycle between daytime napping and DSPS appears to be the most plausible model.

Despite the novelty of the results, the following limitations should be considered. First, while the results remained robust above and beyond sociodemographic, socioeconomic, and physiological confounders, the cross-sectional design does not allow for a causal relationship between DSPS, daytime napping, and MetS; as such, a bidirectional influence is highly conceivable. Though previous theoretical and meta-analytical data implied that circadian misalignments preceded MetS and not vice versa.[5,6,8,23] Given this, we claim that the statistical approach chosen was justified. Second, psychosocial factors such as being single or having financial issues[43] were not considered. As such, physiological and chronobiological factors to explain DSPS appeared to neglect important psychosocial factors. Third, a major methodological flaw is the coarse-grained definition of daytime naps of "less than 1 hour"; a more fine-grained subdivision of daytime napping in ≤15 minutes, 15-30 minutes, 30-45 minutes and 45-59 minutes would have allowed for a further and more detailed inspection of the associations between daytime napping and MetS. A daytime nap of ≤15 minutes is physiologically not equal to a daytime nap of 45-59 minutes.[44] Fourth, the assessment of delayed (or advanced) sleep phases might pose some issues: While delayed (or advanced) sleep phases are well-defined as circadian rhythm sleep–wake disorders (chapter 4 of the International Classification of Sleep Disorders);[29] much more flexibility is given to the measures to assess such phases. Specifically, in the present study, we employed the Farsi version[30] of the Composite Scale of Morningness (CSM).[31] Other studies with small samples[45,46] the salivary dim-light melatonin onset (DLMO) as an objective physiological assessment. Fifth, the prevalence of sleep apnea was not assessed, though there is sufficient reason to consider the prevalence of sleep apnea as an important factor impacting MetS and sleep patterns, including daytime napping.[47-51] As such, it is conceivable that including sleep apnea in the multiple regression models might have brought additional and important information on the complex association between circadian misalignment, sleep-related issues, and the prevalence of MetS among adults aged 35-65 years. Sixth, while we focused on the relations between sleep patterns and daytime napping, focusing on sleep durations might have further contributed to a fine-grained pattern of results. Given these findings, future studies in this field should be longitudinal and interventional and report participants' sleep duration. Interventional studies to modify lifestyles such as nutritional and physical activity counseling might have the potential to favorably impact sleep schedules, including the reduction of daytime napping. To show the case to this point, Powell and Appelhans[52] proposed a thorough lifestyle modifying program using the Obesity-Related Behavioral Intervention Trials (ORBIT) model for the behavioral treatment among participants with MetS (mean age: 53 years; 77% females). More specifically, the intervention focused on dieting, physical activity and coping with stress, with an intensive 6-month phase followed by monthly, participant-led maintenance meetings for a consecutive 2.5 years. Results showed that 2.5 years later, MetS remission was achieved in about 54% of participants. Similarly, Kim and Chung[53] proposed in their statement to deal with MetS-related health issues among the Korean population by focusing on 6 lifestyle modifications: weight control, smoking cessation, alcohol drinking in moderation, diet control, exercise and physical activity, and cognitive behavioral therapy. Last, given that the prevalence of MetS is associated with risks of cardiovascular diseases and all-cause mortality,[54] appropriate interventions to decrease both MetS and MetS-related mortality are more than justified.

Conclusion

The findings of this study indicate that DSPS and daytime napping are associated with an increased risk of MetS. Interventions that promote a healthier lifestyle and improve sleep quality should be considered as potential ways to decrease the risk and severity of MetS in general.

Availability of Data and Materials: The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Committee Approval: *The Ethics Committee of the Deputy of Research and Technology of the Kermanshah University of Medical Sciences approved the study (KUMS.REC.1394.315).*

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

Peer-review: *Externally peer-reviewed.*

Author Contributions: *Concept – N.H., A.Al., M.M., A.Ah., R.M., M.B., D.S.-B., A.B.B., H.K., S.B.; Design – N.H., A.Al., M.M., A.Ah., R.M., M.B., D.S.-B., A.B.B., H.K., S.B.; Supervision – N.H., A.Al., R.M., D.S.-B., A.B.B., H.K., S.B.; Resources – N.H., A.Al., M.M., A.Ah., R.M., M.B., H.K.; Data collection and processing – N.H., A.Al., M.M., A.Ah., R.M., M.B., H.K.; Analysis and interpretation – N.H., A.Al., M.M., A.Ah., R.M., M.B., D.S.-B., A.B.B., H.K., S.B.; Literature search – N.H., A.Al., M.M., A.Ah., R.M., M.B., D.S.-B., A.B.B., H.K., S.B.; Writing and critical review – N.H., A.Al., M.M., A.Ah., R.M., M.B., D.S.-B., A.B.B., H.K., S.B.*

Acknowledgements: *The authors are deeply grateful to the investigators of the PERSIAN study for their invaluable support. They assisted in designing the research methods, developing the questionnaire, and coordinating the interviewers, RaNCD staff, and the Ravansar population who participated in data collection for this research project.*

Declaration of Interests: *The authors have no conflicts of interest to declare.*

Funding: *Ministry of Health, the Medical Education of Iran, and the Kermanshah University of Medical Sciences (Grant No.: 92472) supported this study.*

References

1. Saklayen MG. The global epidemic of the metabolic syndrome. *Curr Hypertens Rep*. 2018;20(2):12. [CrossRef]
2. Kassi E, Pervanidou P, Kaltsas G, Chrousos G. Metabolic syndrome: definitions and controversies. *BMC Med*. 2011;9:48. [CrossRef]
3. Ansarimoghaddam A, Adineh HA, Zareban I, Iranpour S, HosseinZadeh A, Kh F. Prevalence of metabolic syndrome in Middle-East countries: meta-analysis of cross-sectional studies. *Diabetes Metab Syndr*. 2018;12(2):195-201. [CrossRef]
4. Kalan Farmanfarma K, Kaykhaei MA, Adineh HA, Mohammadi M, Dabiri S, Ansari-Moghaddam A. Prevalence of metabolic syndrome in Iran: A meta-analysis of 69 studies. *Diabetes Metab Syndr*. 2019;13(1):792-799. [CrossRef]
5. Chasens ER, Imes CC, Kariuki JK, et al. Sleep and metabolic syndrome. *Nurs Clin North Am*. 2021;56(2):203-217. [CrossRef]
6. Mentzelou M, Papadopoulou SK, Papandreou D, et al. Evaluating the relationship between circadian rhythms and sleep, metabolic and cardiovascular disorders: current clinical evidence in human studies. *Metabolites*. 2023;13(3). [CrossRef]
7. McHill AW, Melanson EL, Higgins J, et al. Impact of circadian misalignment on energy metabolism during simulated nightshift work. *Proc Natl Acad Sci U S A*. 2014;111(48):17302-17307. [CrossRef]
8. Chaput JP, McHill AW, Cox RC, et al. The role of insufficient sleep and circadian misalignment in obesity. *Nat Rev Endocrinol*. 2023;19(2):82-97. [CrossRef]
9. Culnan E, McCullough LM, Wyatt JK. Circadian rhythm sleep-wake phase disorders. *Neurol Clin*. 2019;37(3):527-543. [CrossRef]
10. Typaldos M, Sockrider M. Delayed sleep phase syndrome. *Am J Respir Crit Care Med*. 2019;200(4):P7-P8. [CrossRef]
11. Curcio G, Ferrara M, De Gennaro L. Sleep loss, learning capacity and academic performance. *Sleep Med Rev*. 2006;10(5):323-337. [CrossRef]
12. Goldstein AN, Walker MP. The role of sleep in emotional brain function. *Annu Rev Clin Psychol*. 2014;10:679-708. [CrossRef]
13. van der Helm E, Gujar N, Walker MP. Sleep deprivation impairs the accurate recognition of human emotions. *Sleep*. 2010;33(3):335-342. [CrossRef]
14. Walker MP, Harvey AG. Obligate symbiosis: sleep and affect. *Sleep Med Rev*. 2010;14(4):215-217. [CrossRef]
15. Abdoli N, Sadeghi Bahmani DS, Farnia V, et al. Among substance-abusing traffic offenders, poor sleep and poor general health predict lower driving skills but not slower reaction times. *Psychol Res Behav Manag*. 2018;11:557-566. [CrossRef]
16. Abdoli N, Farnia V, Delavar A, et al. Mental health status, aggression, and poor driving distinguish traffic offenders from non-offenders but health status predicts driving behavior in both groups. *Neuropsychiatr Dis Treat*. 2015;11:2063-2070. [CrossRef]
17. Bioulac S, Micoulaud-Franchi JA, Arnaud M, et al. Risk of motor vehicle accidents related to sleepiness at the wheel: A systematic review and meta-analysis. *Sleep*. 2017;40(10). [CrossRef]
18. Garbarino S, Magnavita N, Guglielmi O, et al. Insomnia is associated with road accidents. Further evidence from a study on truck drivers. *PLOS ONE*. 2017;12(10):e0187256. [CrossRef]
19. American Academy of Sleep Medicine Board of Directors, Watson NF, Morgenthaler T, et al. Confronting drowsy driving: the American Academy of Sleep Medicine perspective. *J Clin Sleep Med*. 2015;11(11):1335-1336. [CrossRef]
20. Ben Simon E, Walker MP. Sleep loss causes social withdrawal and loneliness. *Nat Commun*. 2018;9(1):3146. [CrossRef]
21. Lee JH, Cho J. Sleep and obesity. *Sleep Med Clin*. 2022;17(1):111-116. [CrossRef]
22. Maury E, Hong HK, Bass J. Circadian disruption in the pathogenesis of metabolic syndrome. *Diabetes Metab*. 2014;40(5):338-346. [CrossRef]
23. Wolk R, Somers VK. Sleep and the metabolic syndrome. *Exp Physiol*. 2007;92(1):67-78. [CrossRef]
24. Qian YX, Liu JH, Ma QH, Sun HP, Xu Y, Pan CW. Associations of sleep durations and sleep-related parameters with metabolic syndrome among older Chinese adults. *Endocrine*. 2019;66(2):240-248. [CrossRef]
25. Zimmet P, Alberti KGMM, Stern N, et al. The Circadian Syndrome: is the Metabolic Syndrome and much more! *J Intern Med*. 2019;286(2):181-191. [CrossRef]
26. Pasdar Y, Najafi F, Moradinazar M, et al. Cohort Profile: Ravansar non-communicable disease cohort study: the first cohort study in a Kurdish population. *Int J Epidemiol*. 2019;48(3):682-683f. [CrossRef]
27. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA*. 2013;310(20):2191-2194. [CrossRef]
28. First M. *Structured Clinical Interview for the DSM (SCID)*; 2015:1-6.
29. American Academy of Sleep Medicine. *The International Classification of Sleep Disorders*. 3rd ed ed. Darien IL: American Academy of Sleep Medicine; 2014.
30. Rahimi Pordanjani T, Ebrahimi AM. Psychometric properties of Persian version of Composite Scale of morningness. *Asian J Psychiatr*. 2017;25:260-266. [CrossRef]
31. Smith CS, Reilly C, Midkiff K. Evaluation of three circadian rhythm questionnaires with suggestions for an improved measure of morningness. *J Appl Psychol*. 1989;74(5):728-738. [CrossRef]
32. Soofi M, Najafi F, Soltani S, Karamimatin B. Measurement and decomposition of socioeconomic inequality in metabolic syndrome: A cross-sectional analysis of the RaNCD cohort study in the west of Iran. *J Prev Med Public Health = Yebang Uihakhoe chi*. 2023;56(1):50-58. [CrossRef]
33. Jetté M, Sidney K, Blümchen G. Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. *Clin Cardiol*. 1990;13(8):555-565. [CrossRef]
34. Ainsworth BE, Haskell WL, Herrmann SD, et al. 2011 Compendium of Physical Activities: a second update of codes and MET values. *Med Sci Sports Exerc*. 2011;43(8):1575-1581. [CrossRef]
35. National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and

treatment of high blood cholesterol in adults (Adult Treatment Panel III) final report. *Circulation*. Adult Treatment Panel III [final report]. 2002;106(25):3143-3421. [CrossRef]
36. Lee AM, Gurka MJ, DeBoer MD. A metabolic syndrome severity score to estimate risk in adolescents and adults: current evidence and future potential. *Expert Rev Cardiovasc Ther*. 2016;14(4):411-413. [CrossRef]
37. Parameshwar A, Maiya GA, Kamath SU, Shastry BA, Ravishankar. Lifestyle modification with physical activity promotion on leptin resistance and quality of life in metabolic syndrome - A systematic review with meta-analysis. *Curr Diabetes Rev*. 2021;17(3):345-355. [CrossRef]
38. Yamaoka K, Tango T. Effects of lifestyle modification on metabolic syndrome: a systematic review and meta-analysis. *BMC Med*. 2012;10:138. [CrossRef]
39. Mbatchou Ngahane BH, Nganda MM, Dzudie A, et al. Prevalence and determinants of excessive daytime sleepiness in hypertensive patients: a cross-sectional study in Douala, Cameroon. *BMJ Open*. 2015;5(7):e008339. [CrossRef]
40. Millman RP, Working Group on Sleepiness in Adolescents/Young Adults, AAP Committee on Adolescence. Excessive sleepiness in adolescents and young adults: causes, consequences, and treatment strategies. *Pediatrics*. 2005;115(6):1774-1786. [CrossRef]
41. Paine SJ, Fink J, Gander PH, Warman GR. Identifying advanced and delayed sleep phase disorders in the general population: a national survey of New Zealand adults. *Chronobiol Int*. 2014;31(5):627-636. [CrossRef]
42. Svensson M, Franklin KA, Theorell-Haglöw J, Lindberg E. Daytime sleepiness relates to snoring independent of the apnea-hypopnea index in women from the general population. *Chest*. 2008;134(5):919-924. [CrossRef]
43. Sivertsen B, Harvey AG, Gradisar M, Pallesen S, Hysing M. Delayed sleep-wake phase disorder in young adults: prevalence and correlates from a national survey of Norwegian university students. *Sleep Med*. 2021;77:184-191. [CrossRef]
44. Wang Y, Zeng Y, Zhang X, et al. Daytime napping duration is positively associated with risk of hyperuricemia in a Chinese population. *J Clin Endocrinol Metab*. 2021;106(5):e2096-e2105-e105. [CrossRef]
45. Watson LA, McGlashan EM, Hosken IT, Anderson C, Phillips AJK, Cain SW. Sleep and circadian instability in delayed sleep-wake phase disorder. *J Clin Sleep Med*. 2020;16(9):1431-1436. [CrossRef]
46. Wyatt JK, Stepanski EJ, Kirkby J. Circadian phase in delayed sleep phase syndrome: predictors and temporal stability across multiple assessments. *Sleep*. 2006;29(8):1075-1080. [CrossRef]
47. Kong DL, Qin Z, Wang W, Pan Y, Kang J, Pang J. Association between obstructive sleep apnea and metabolic syndrome: a meta-analysis. *Clin Invest Med*. 2016;39(5):E161-E172-e72. [CrossRef]
48. Nadeem R, Singh M, Nida M, et al. Effect of obstructive sleep apnea hypopnea syndrome on lipid profile: a meta-regression analysis. *J Clin Sleep Med*. 2014;10(5):475-489. [CrossRef]
49. Qian Y, Xu H, Wang Y, Yi H, Guan J, Yin S. Obstructive sleep apnea predicts risk of metabolic syndrome independently of obesity: a meta-analysis. *Arch Med Sci*. 2016;12(5):1077-1087. [CrossRef]
50. Sarokhani M, Goli M, Salarvand S, Ghanei Gheshlagh R. The prevalence of sleep apnea in Iran: a systematic review and meta-analysis. *Tanaffos*. 2019;18(1):1-10.
51. Xu S, Wan Y, Xu M, et al. The association between obstructive sleep apnea and metabolic syndrome: a systematic review and meta-analysis. *BMC Pulm Med*. 2015;15:105. [CrossRef]
52. Powell LH, Appelhans BM, Ventrelle J, et al. Development of a lifestyle intervention for the metabolic syndrome: discovery through proof-of-concept. *Health Psychol*. 2018;37(10):929-939. [CrossRef]
53. Kim HL, Chung J, Kim KJ, et al. Lifestyle modification in the management of metabolic syndrome: statement from Korean society of cardiometabolic syndrome (KSCMS). *Korean Circ J*. 2022;52(2):93-109. [CrossRef]
54. He D, Zhang X, Chen S, et al. Dynamic changes of metabolic syndrome alter the risks of cardiovascular diseases and all-cause mortality: evidence from a prospective cohort study. *Front Cardiovasc Med*. 2021;8:706999. [CrossRef]