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The Association between Sleep Pattern with Lipid Profile and Obesity among Adults in Yazd: Cross-Sectional Analysis of Shahedieh Cohort Study

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ABSTRACT

Background: Lifestyle changes, such as changes in sleep patterns and insufficient sleep have led to an increase in obesity and hyperlipidemia. The present study was conducted to investigate the association between abnormal lipid profile and obesity with sleep pattern among adult in Yazd adults in Shahedieh cohort study. **Methods:** This analytic cross-sectional study was carried out on the data of the enrollment phase of Shahedieh cohort study conducted in Yazd Greater Area during 2015-2017. In this study, all adults aged 35-70 years from Shahedieh, Zarch, and Ashekzar cities were investigated. The data used in this study included demographic and sleep variables, as well as triglyceride (TG), cholesterol (TC), high density lipoprotein cholesterol (HDL-c) and low density lipoprotein cholesterol (LDL-c). **Results:** The results showed that 4765 participants were male, and 4768 were female, and most of the them were overweight (42.4%) or obese (34.2%). The results showed that long-term sleep (> 8 hours at night) is correlated with high serum TC (P = 0.009) and TG (P = 0.009). Sleep latency is related with an increase in TC (r=0.03, P = 0.004), TG (r=0.04, P = 0.001), and LDL-c (r = 0.04, P = 0.001). Moreover, the duration of daytime sleep increases by increasing TG (r = 0.06, P = 0.001) and decreasing HDL-c (r = -0.07, P = 0.001). The results also showed that TG were significantly higher in people with periodic limb movement in sleep (P = 0.02). The number of people who used sleeping pills increased by increasing TG (P = 0.01) and body mass index (BMI) decreased by increasing sleep duration (P = 0.21). **Conclusion:** The results of this study showed that long-term sleep increases TC and TG. The findings showed a correlation between long sleep duration and decreased BMI.

Keywords: *Lipids; Obesity; Sleep; Cohort studies*

Introduction

Cardiovascular disease (CVD) is one of the leading causes of death worldwide (Lozano R *et al.*, 2012). The World Health Organization (WHO) has introduced cardiovascular diseases as the most important factor of disability and death. The WHO has reported that 17.9 million people died from cardiovascular diseases globally in 2019, representing 32% of all global deaths (World Health Organization, 2021) . In addition, over 75% of these deaths take place in developing countries.

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The incidence and death rate of cardiovascular diseases has increased in recent years in Iran (Provincial Committee for Prevention and Control of Non-Communicable Diseases and Related Risk Factors, 2020). Demographic-social variables (such as age, gender) and lifestyle variables (such as blood pressure, lipid profiles, physical activity, obesity, and smoking) and some diseases, such as type 2 diabetes are some of the common risk factors for CVD (Yazdanpanah *et al.*, 2020).

Abnormal blood lipid factors, such as high levels of total cholesterol (TC), low density lipoprotein cholesterol (LDL-c), triglyceride (TG), and low levels of high density lipoprotein cholesterol (HDL-c), increase the risk of cardiovascular disease. To prevent cardiovascular disease and reduce its mortality, it is also important to pay attention to various aspects of lifestyle**.** In the STEPS study of 2016, the situation of Yazd province in terms of the prevalence of high cholesterol in the population aged over 18 years with a prevalence of 23.2% (national prevalence = 22.6%) ranked fourteenth. Moreover, in terms of hypertriglyceridemia with a prevalence of 38.5% (national prevalence = 28), it ranked first in the country (Provincial Committee for Prevention and Control of Non-Communicable Diseases and Related Risk Factors, 2020).

Adequate sleep is an effective element in physical and mental health (Alfonsi *et al.*, 2020). Adequate sleep provides physical restoration through improving anabolic functions, such as protein and tissue synthesis (Erickson *et al.*, 2003). Sleep disorders include a wide range of symptoms, such as short and long sleep duration, taking a nap during the day (without authority), waking up at night, sleep latency, and use of sleeping medications (Wang *et al.*, 2020).

Some researchers have studied the relationship between sleep and lipid profile (TC, HDL-c, LDL-c, and TG) (Aho *et al.*, 2016, Kinuhata *et al.*, 2014, Lin *et al.*, 2017, Zheng *et al.*, 2015). Abdurahman et al. showed that based on the adjusted odds ratio (AOR), long sleep duration was significantly associated with higher TC risk. However, neither short nor long sleep was associated with an increased risk of high LDL-c and TG levels and low HDL-c levels (Abdurahman *et al.*, 2020).

Due to lifestyle changes and subsequent changes in sleep patterns, insufficient sleep, and high prevalence of cardiovascular disease, finding a link between sleep and lipid profiles can be effective in improving lifestyle, designing educational interventions, and ultimately reducing mortality from heart disease. The present study aims to investigate the association between abnormal lipid profile and obesity with sleep pattern among adults in Shahedieh cohort study.

Materials and Methods

Type of study and participants: The present cross-sectional study was conducted on the data of the recruitment phase of the Shahedieh cohort study which was carried out in Shahedieh, Ashkezar, and Zarch cities, Yazd, Iran on adults aged 35-70 years during 2015-2017. Shahedieh cohort study is part of the PERSIAN cohort study conducted in different provinces of Iran to assess the prevalence of non-communicable and occupational diseases and their related risk factors. A total of 9533 adults aged 35–70 years who live in three cities of Yazd Greater Area (Shahedieh, Zarch, and Ashkezar) were included to in the cohort study.

The enrollment phase in Shahedieh was started at April 2015 and finished at August 2016. The enrollment phase in Zarch and Ashkezar was started at August 2016 and finished on September 2017(Kazemipoor *et al.*, 2019). The inclusion criteria included being from Iranian descent, age of 35–70 years, residing in Shahedieh, Zarch, and Ashkezar regions for at least 9 months, and giving informed consent to participate in the study.

Qualified participants were invited to collect biological samples with fasting state and provide data on general characteristics (demographic characteristics, socioeconomic status, employment status, fuel status and location, lifestyle habits, history of chronic diseases, history of family illnesses, history of smoking and drug use, oral health, sleep, and food habits). The information was collected by trained interviewers.

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Measurements: The variables used in this study included 1- General characteristics (age, gender, occupation, marital status, body mass index (BMI)), 2- The required data regarding sleep (the common bedtime, the usual time to wake up in the morning, periodic limb movement in sleep (PLMS), taking a nap during the day without specific activity, and taking sleeping pills more han twice a week), and 3- Lipid profile parameters (TG, TC, HDL-c, and LDL-c).

Blood samples (25 ml) were taken from the participants in the fasting state. To measure the serum lipid profile, people were fasting for 12 hours. Then, the samples were transported to the laboratory and a BT-1500 Autoanalyzer (BT-1500, Biotechnica, Italy) was used for biochemical testing. The abnormal lipid profile parameters in the present study were defined based on an expert panel in Shahedieh cohort study, including TG ≥ 150 mg/dl, TC ≥ 200 mg/dl), LDL-c ≥ 130 mg/dl, and HDL-c ≤ 35 mg /dl. Sleep duration 8 > hours and <6 hours during the night was considered as long-term sleep and short-term sleep, respectively (Abdurahman *et al.*, 2020). On the other hand, height was measured using a stadiometer with an accuracy of 0.1 cm, and weight was measured using a digital scale with an accuracy of 0.1 kilograms. Based on the BMI, the weight of the subjects was classified into underweight (BMI < 18.5 kg/m^2), normal (BMI: 18.5- < 25 kg/m^2), overweight (BMI: 25-30 kg/m^2), and obese (BMI > 30 kg/m^2). BMI was calculated by weight (kg) divided by square of height (m).

Data analysis: Data was performed in SPSS version 20.0 using descriptive statistics, Chi-square, independent t-test, the analysis of variance (One-way ANOVA), Pearson correlation, and logistic regression analysis. In all the statistical analyses, a P-value of less than 0.05 was considered significant. This article was approved by the research ethics committees of Shahid Sadoughi University of Medical Sciences, code IR.SSU.SPH.REC.1399.043.

Results

The results of the present study showed that 4765 participants were male, and 4768 were female, 95.7% were married, and the majority of the them (56.2%) were unemployed (**Table 1**). **Table 1** shows that most of the participants were overweight (42.4%) and obese (34.2%).

The results of the present study showed that the frequency of long-term sleep (> 8 hours) increased by increasing TC (*P* = 0.009), TG (*P* = 0.009), and LDL-c (*P* = 0.06), and by decreasing HDL-c (*P* = 0.95) (**Table 2**). According to logistic regression, in people with long-term sleep (>8 hours), the chance of high TG was 15% (*P* = 0.007, OR=1.15, CI=1.04-1.28), the chance high TC was 13% (*P* = 0.007, OR=1.13, CI =1.03-1.25) and the chance of high LDL-c was 14% higher than other people (*P* = 0.02, OR=1.14, CI=1.08-1.34).

The results of Pearson correlation showed that blood lipids profile was directly and significantly associated with sleep latency. So that sleep latency increased by increasing cholesterol (r = 0.03, *P* = 0.004), TG (r = 0.04, *P* = 0.001), and LDL-c (r = 0.04, *P* = 0.001). Logistic regression results also showed that in people with sleep higher than 15 minutes, the chance of high TC was 17% (*P* = 0.001, OR=1.17, CI=1.06-1.28) and the chance of high LDL-c was 20% higher than other people (*P* = 0.001, OR=1.20, CI=1.08-1.34).

The current study indicates that lipid profile parameter was higher in people who slept during the day. So that, people with higher TG (P = 0.001), TC (*P* = 0.49), and LDL-c (*P* = 0.53), as well as lower HDL-c (*P* = 0.006), reported sleeping during the day. Pearson correlation showed that the duration of sleep during the day increased significantly by increasing triglyceride (r = 0.06, *P* = 0.001) and decreasing HDL-c (r = -0.07, *P* = 0.001).

The results also showed that TG levels were significantly higher in people with PLMS (*P* = 0.02) (**Table 3**). The findings of the study showed that the number of people who used sleeping medications (more than twice a week) increased with an increase in blood TG (*P* = 0.01) (**Table 3**).

Table 4 reveals that BMI decreased by increasing sleep duration (*P* = 0.21). According to the results, people who had sleep latency > 15 min

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(P = 0.006), PLMS (P = 0.001), and people who slept during the day (P = 0.001) or took sleeping pills regularly (P = 0.001) had higher BMI.

Further analysis showed that the chance of overweight and obese (BMI >25 kg/m^2) in people with daytime nap was 28% (P = 0.001, OR=1.28, CI=1.15-1.42), in people who used sleeping pills was 33% (P = 0.004, OR=1.33, CI=1.09-1.62), and in people with sleep latency higher than 15 min was 13% higher than other people (P =0.02, OR=1.13, CI=1.02-1.25) (**Table 5**).

Table 1. Demographic characteristics of adults aged 35-70 years participating in the Shahedieh cohort study.

Variables	n	%
Gender		
Women	4765	50.0
Men	4768	50.0
Occupational status		
Yes	4173	45.2
No	5350	54.8
Marital status		
Single	37	0.4
Married	9117	95.7
Widow	324	3.4
Divorced	45	0.5
Body mass index (kg/m^2)		
Underweight (< 18.5)	114	1.2
Normal (18.5-24.9)	2071	22.2
Overweight (25-29.9)	3964	42.4
Obese (30 <)	3194	34.2

Table 2. Frequency of nighttime sleep duration based on blood lipid parameters in adults aged 35-70 years participating in the Shahedieh cohort study.

Variables	Nighttime sleep duration (Hours)			P-value [a]
	< 6	6-8	8 <	
Total cholesterol (mg/dl)				0.009
Normal(< 200)	823 (13.4)[b]	4585 (74.8)	721 (11.8)	
Medium risk (200-240)	335 (13.5)	1833 (74.1)	306 (12.4)	
High risk (240 <)	128 (13.8)	654 (70.3)	148 (15.9)	
High density lipoprotein cholesterol (mg/dl)				0.95
Normal(< 35)	1237 (13.5)	6792 (74.1)	1134 (12.4)	
Medium risk (25-35)	44 (13.35)	249 (75.5)	37 (11.2)	
High risk (25 <)	5 (12.5)	31 (77.5)	4 (10.0)	
Triglyceride (mg/dl)				
Normal(< 200)	958 (13.4)	5333 (74.8)	840 (11.8)	0.009
Medium risk (200-400)	282 (13.2)	1564 (73.1)	294 (13.7)	
High risk (400 <)	46 (17.6)	175 (66.8)	41 (15.6)	
Low density lipoprotein cholesterol (mg/dl)				0.06
Normal(<130)	998 (13.3)	5613 (74.7)	899 (12.0)	
Medium risk (130-160)	203 (14.2)	1049 (73.3)	179 (12.5)	
High risk (> 160)	60 (13.0)	325 (70.7)	75 (16.3)	

[a]: *ANOVA test*; [b]: *n (%).*

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Table 3. Mean (±SD) of blood lipid parameters based on daytime nap, periodic limb movement in sleep (PLMS), and use of sleeping pills in adults aged 35-70 years participating in the Shahedieh cohort study.

Variables	Triglyceride (mg/dl)	Total cholesterol (mg/dl)	Low density lipoprotein cholesterol (mg/dl)	High density lipoprotein cholesterol (mg/dl)
Sleep during the day				
Yes	168.6 ± 105.6	189.0 ± 41.8	104.4 ± 32.5	52.2 ± 12.1
No	160.3 ± 95.8	188.4 ± 41.0	103.9 ± 32.5	53.3 ± 12.3
P-value [a]	0.001	0.49	0.53	0.006
Periodic limb movement in sleep				
Yes	173.0 ± 115.5	190.9 ± 40.6	104.8 ± 32.3	52.8 ± 12.5
No	165.5 ± 115.5	188.6 ± 41.7	104.2 ± 32.5	52.7 ± 12.1
P-value	0.02	0.09	0.73	0.54
Use of sleeping medications				
Yes	175.7 ± 119.6	189.2 ± 48.3	102.2 ± 34.6	53.5 ± 13.5
No	165.5 ± 101.4	188.8 ± 41.0	104.4 ± 32.3	52.1 ± 11.7
P-value	0.01	0.84	0.06	0.07

[a]: Independent t-test.

Table 4. Mean (±SD) of body mass index based on sleeping variables in adults aged 35-70 years participating in the Shahedieh cohort study.

Variables		P-value
Sleep duration (hour)		0.21 [a]
> 6	28.6 ± 5.2[c]	
6-8	28.4 ± 6.8	
8 <	28.2 ± 5.1	
Sleep latency (min)		0.006 [b]
< 15	28.3 ± 7.0	
15 <	28.7 ± 5.0	
Periodic limb movement in sleep		0.001 [b]
Yes	28.9 ± 5.0	
No	28.3 ± 5.3	
Sleep during the day		0.001 [b]
Yes	28.6 ± 6.4	
No	28.0 ± 6.4	
Using sleeping pills		0.001 [b]
Yes	29.3 ± 5.0	
No	28.4 ± 6.5	

[a]: *ANOVA test;* [b]: *independent t-test; c: Mean* ± SD

Table 5. Logistic regression analysis for predicting overweight and obesity in adults aged 35-70 years participating in the Shahedieh cohort study.

Variables	Crude logistic regression		Adjusted logistic regression			
	OR	P-value	OR	P-value	CI	
					Lower	Upper
Constant			3.04	0.001	-	-
Age (y)	0.9	0.46	-	-	-	-
Marital status	1.26	0.03	1.34	0.02	1.03	1.73
Sleep latency > 15 min	1.14	0.01	1.13	0.02	1.02	1.25
Sleep duration < 6 hours	1.12	0.1	-	-	-	-
Sleep duration > 8 hours	0.88	0.01	0.9	0.05	0.81	1.004
Periodic limb movement in sleep	0.95	0.46	-	-	-	-
Sleep during the day	1.27	0.001	1.28	0.001	1.15	1.42
Using sleeping pills	1.36	0.002	1.33	0.004	1.09	1.62

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Discussion

According to the results of the present study, a significant relationship was observed between blood lipid profiles and sleep-related variables. According to the results, the frequency of long-term sleep (> 8 hours at night) increased by increasing TC and TG. This result is consistent with other studies. Abreu et *al.* reported that there was a significant relationship between blood lipid levels and sleep quality (Abreu *et al.*, 2015) . Arora et *al*. stated that abnormal sleep duration disrupts the metabolic process and consequently increases the risk of metabolic disorders, which was stronger for adults aged 36-50 years (Arora *et al.*, 2020). Azadbakht *et al*. suggested that cholesterol levels among boys have a positive correlation with sleep duration, and long-term sleep can increase cholesterol levels (Azadbakht *et al.*, 2013). Mastura et *al*. pointed out that the chance of high TC (> 200 mg/dl) in people with poor sleep quality was 5.78 times higher than other people (Mastura and Budiningsih, 2016).

The findings of the current study are consistent with lee et *al*. who found that people who slept longer than 10 hours had higher triglyceride levels (Lee and Park, 2014). This finding is consistent with other studies (Arora T *et al.*, 2011, Kaneita Y *et al.*, 2008, Sung V *et al.*, 2011). According to Collier's study, TC levels increased per or each additional hour. According to the author's comment, the relationship between sleep quality and blood lipids parameters can strengthen the positive correlation between sleep and heart disease (Collier, 2020).

The results of the present study show that people with PLMS, sleep latency, daytime nap, and people who used sleeping pills more than twice a week had higher blood triglyceride levels. This finding is in agreement with Wei et al.'s study, which showed that sleep problems, such as short or long-term sleep, snoring, sleep latency, and use of sleeping pills increase the TG / HDL-c ratio in adults (Wei *et al.*, 2020). The results of the study by Yeon-Gyung and Hyoung-Sook also showed that people with Restless Legs Syndrome (RLS) had poorer sleep quality, and often suffer from dyslipidemia. However, the authors believed that this correlation need further investigations (Yeon-Gyung and Hyoung-Sook, 2011).

The main mechanism of the relationship between sleep and abnormal lipid profiles is not clear, and there might be a two-way relationship. Several studies have shown that long-term sleep is associated with obesity (Tan *et al.*, 2018), high blood pressure (Kim *et al.*, 2018), diabetes, and glucose intolerance (Ayas *et al.*, 2003, Gottlieb *et al.*, 2005). It is also possible that the relationship between sleep duration and abnormal lipid profiles is due to common risk factors, such as smoking and alcohol consumption (Song *et al.*, 2020). However, these results differ from some published studies (Kong *et al.*, 2011, Zhan *et al.*, 2014). In Rey-Lopeze et *al*. study, no significant correlation was observed between sleep duration and dyslipidemia (Rey-López *et al.*, 2014). Differences in the age distribution of the studied populations, lifestyle, socioeconomic status, incomplete control of confounders, and different classifications for blood lipid levels can be the reasons for differences in the results of the studies (Rey-López *et al.*, 2014, Sabanayagam and Shankar, 2012, Zhan *et al.*, 2014).

The current study suggests an inverse correlation between BMI and sleep duration. In the current study, people with longer sleep duration had significantly lower BMI than people who had shorter sleep duration. The relationship between sleep duration and BMI in the present study was consistent with Fasa PERSIAN Cohort Study (Yazdanpanah *et al.*, 2020).The findings of the present study are in line with different studies (Dashti *et al.*, 2015, Watson *et al.*, 2010).

Another important finding was that the possibility of overweight and obesity (BMI >25 kg/m^2) in people with the daytime nap, in people who used sleeping pills, and in people with sleep latency higher than 15 min was higher than other people. A study by Lai and Say showed that there is an inverse relationship between sleep duration and BMI (Lai and Say, 2013). This finding is in line with the study by Azadbakht et *al.*, which showed a significant relationship between sleep

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quality and BMI (Azadbakht *et al.*, 2013). However, the findings of the current study do not support some studies (Moshkovich, 2013, Sung *et al.*, 2011) . Some experimental studies have shown that short-term sleep by increasing ghrelin and decreasing leptin concentrations (Taheri *et al.*, 2004), as well as increasing energy consumption in the body (Patterson *et al.*, 2014) increased appetite and desire to eat, leading to obesity (Dashti *et al.*, 2015). The main limitation of this study was the lack of access to polysomnography. The other limitation of the present study is the lack of a standard questionnaire (such as Pittsburgh Sleep Quality Index) to collect sleep-related information in the PERSIAN cohort study. One of the strengths of the present study was the large number of samples, resulting in more accurate results.

Conclusion

The results of this study showed that long-term sleep increases cholesterol and triglyceride. The findings showed a correlation between long sleep duration and decreased BMI. However, more prospective analyses are required to warrant these findings. Considering that abnormal lipid profiles lead to an increased risk of cardiovascular disease, it is recommended to identify people at risk and improve their sleep habits. It is suggested that nurses and other medical groups pay more attention to the patients' sleep pattern and quality of at the time of obtaining the history of the disease, and provide the basis for improving the quantity and quality of sleep by teaching self-care measures.

Conflict of interest

The authors declare that there is no conflict of interest.

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Authors' contributions

Momayyezi M and Fallahzadeh H conceived and developed the idea for the article; Mirzaei M collected the data; Momayyezi M, Fakhravari L, and Fallahzadeh H prepared numerous drafts; Momayyezi M and Fallahzadeh H contributed to the statistical analysis; Fallahzadeh H, Momayyezi M, Fakhravari L, and Mirzaei M revised the manuscript. All the authors read and approved the final manuscript.

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