Association Between Sleep Chronotype and Dyslipidemia in a Population Aged 40-65 Years: Postprint

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Abstract

Background Late sleep behavior among middle-aged and older adults may affect blood lipid metabolism, yet the association between them requires further in-depth analysis. Objective To analyze the association between sleep chronotype and dyslipidemia in individuals aged 40-65 years across different subpopulations stratified by gender, central obesity, pre-sleep snacking, and smoking status. Methods An unconditional binary logistic regression model was employed to assess the association between sleep chronotype and the risk of various dyslipidemia indicators. Stratified analyses were conducted by gender, central obesity, pre-sleep snacking, and smoking status. Sensitivity analysis was performed to exclude the influence of shift work. Results In the total population, evening chronotype showed a positive association with dyslipidemia [OR (95%CI) = 1.53 (1.09, 2.14)]. Evening-type individuals exhibited higher risks of hypertriglyceridemia (OR=1.48) and low HDL-C (OR=1.74) compared to morning-type individuals. Stratified analysis revealed that among males (OR=1.78) and centrally obese populations (OR=1.68), evening-type individuals had a higher risk of low HDL-C than morning-type individuals; these differences were not statistically significant in females and non-centrally obese populations (all P>0.05). In the pre-sleep snacking population, evening-type individuals had a higher risk of hypertriglyceridemia (OR=3.76). Among males, the smoking group with evening chronotype showed higher risks of hypertriglyceridemia (OR=1.78) and low HDL-C (OR=1.81) compared to morning-type individuals. No statistically significant differences in dyslipidemia risk were observed among non-centrally obese populations, non-pre-sleep snacking populations, and non-smoking populations (all P>0.05). Conclusion Among individuals aged 40-65 years, evening sleep preference may be a risk factor for dyslipidemia. The association between sleep chronotype and dyslipidemia may vary across populations stratified by gender, central obesity, pre-sleep snacking, and smoking status.

Full Text

Association between Chronotype and Dyslipidemia Among Population Aged 40-65 Years

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Abstract

Background: Late bedtime behavior among middle-aged and elderly individuals may affect lipid metabolism, but the association between sleep timing patterns and dyslipidemia requires further investigation.

Objective: To analyze the association between chronotype and dyslipidemia in 40-65-year-olds, stratified by gender, central obesity, bedtime snacking, and smoking status.

Methods: We used unconditional binary logistic regression models to evaluate associations between chronotype and the risk of various dyslipidemia indicators. Stratified analyses were performed by gender, central obesity, bedtime snacking, and smoking. Sensitivity analysis was conducted to exclude the influence of shift work.

Results: In the total population, evening chronotype was positively associated with dyslipidemia [OR (95%CI) = 1.53 (1.09, 2.14)]. Evening-type individuals had higher risks of hypertriglyceridemia (OR = 1.48) and low HDL-C (OR = 1.74) compared to morning-type individuals. Stratified analysis revealed that among males (OR = 1.78) and those with central obesity (OR = 1.68), evening-type individuals had higher risks of low HDL-C than morning types, while no significant differences were observed in females or non-central obese individuals (both $P > 0.05$). Among those who snacked before bedtime, evening types had a significantly elevated risk of hypertriglyceridemia (OR = 3.76). In male smokers, evening-type individuals showed higher risks for hypertriglyceridemia (OR =

1.78) and low HDL-C (OR = 1.81) compared to morning types. No significant between-group differences in dyslipidemia risk were found among non-central obese individuals, those who did not snack before bedtime, or non-smokers (all $P > 0.05$).

Conclusion: Evening chronotype preference may be a risk factor for dyslipidemia in 40–65-year-olds. The association between chronotype and dyslipidemia may vary across subgroups defined by gender, central obesity, bedtime snacking, and smoking status.

Keywords: chronotype; circadian rhythm; evening type; morning type; dyslipidemia

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Introduction

Dyslipidemia is a major risk factor for cardiovascular disease, and its effective prevention is crucial for cardiovascular disease control [1]. Sleep factors influence lipid metabolism in adults [2], yet most research has focused on sleep duration rather than chronotype [3]. Chronotype refers to an individual' s circadian preference for activity-sleep patterns within a 24-hour period [4]. Middle-aged and elderly populations exhibit high rates of late sleeping [5], and evening-type individuals engage in more unhealthy behaviors compared to morning types, such as smoking and bedtime snacking [6], which are associated with lipid metabolism. Previous studies suggest that the association between chronotype and dyslipidemia may differ by gender and smoking status. A Korean population study found that chronotype was associated with dyslipidemia only in women, not in men [7]. Smoking and obesity are common risk factors for dyslipidemia in middle-aged and elderly populations, with central obesity showing stronger associations with dyslipidemia than general overweight/obesity [8]. Bedtime snacking also affects lipid levels. Furthermore, associations between chronotype and specific lipid indicators may vary. Among middle-aged adults [9], evening preference was associated with low HDL-C levels, whereas among overweight nurses [10], it was associated with high LDL-C levels. Therefore, this study investigates the association between chronotype and different lipid indicators in middle-aged and elderly populations, examining variations by gender, central obesity, bedtime snacking, and smoking status to provide data supporting individualized dyslipidemia prevention strategies.

Methods

1.1 Study Population Data were derived from the baseline survey of a follow-up study on sleep characteristics and chronic diseases among middle-aged and elderly populations in Guizhou Province. From March to August 2022, all eligible individuals at the Physical Examination Center of the First People's Hospital

of Fuquan City were surveyed after providing informed consent. Inclusion criteria were: (1) aged 40-65 years; (2) enterprise/institution employees undergoing annual physical examinations at the center. Exclusion criteria included: (1) severe cardiovascular or cerebrovascular diseases (coronary heart disease, myocardial infarction, angina, atrial fibrillation, chronic heart failure, stroke); (2) major surgeries (brain tumor resection, arterial bypass, organ transplantation); (3) occupational exposure to dust, noise, or coke oven hazards within 5 years; (4) refusal to provide informed consent; (5) inability to participate in smart bracelet follow-up (silicone allergy, pacemaker use). By August 29, 2022, 707 individuals completed the survey. After excluding 7 with incomplete examination data and 1 with uncalculable sleep duration, 699 participants were included in the final analysis.

1.2 Methods and Definitions 1.2.1 Data Collection

Trained professionals conducted physical examinations, questionnaires, and laboratory tests after obtaining informed consent. A self-designed sleep and health questionnaire collected demographic information, medical history, and sleep patterns. Waist circumference was measured at the midpoint between the iliac crest and lower rib margin, and hip circumference at the maximum gluteal circumference (precision: 0.1 cm) to calculate waist-hip ratio (WHR). Laboratory tests included total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) from 5 mL fasting venous blood samples collected in the morning.

1.2.2 Definitions

Chronotype: Based on the Morningness-Eveningness Questionnaire (MEQ) [11] self-assessment: "If people are divided into 'morning type' and 'evening type,' which do you consider yourself?" Responses were: definite evening type; more evening than morning; more morning than evening; definite morning type. Responses or were classified as "evening type" (E-type) and or as "morning type" (M-type) [12].

Dyslipidemia: According to the Chinese Guidelines for Prevention and Treatment of Dyslipidemia [13]: TC $\geq$ 6.2 mmol/L (hypercholesterolemia), LDL-C $\geq$ 4.1 mmol/L (high LDL-C), HDL-C $<$ 1.0 mmol/L (low HDL-C), TG $\geq$ 2.3 mmol/L (hypertriglyceridemia). Dyslipidemia was defined as meeting any one criterion or self-reported diagnosis by community health centers or higher-level hospitals. Non-HDL-C (TC - HDL-C) abnormality was defined as $\geq$ 4.9 mmol/L.

Central Obesity: WHR $\geq$ 0.90 for men and $\geq$ 0.85 for women [14].

Smoking: Current or former smokers.

Bedtime Snacking: Consumption of late-night meals, barbecue, or snacks within 2 hours of bedtime during the past month.

1.3 Statistical Analysis Data were analyzed using R software (version 4.1.2). Normally distributed continuous variables were expressed as mean ± standard deviation (± S) and compared between groups using t-tests. Non-normally distributed data were presented as median (P25, P75) and compared using Mann-Whitney U tests. Categorical variables were described using frequencies and percentages, with ^{2} tests for group comparisons. Unconditional binary logistic regression models assessed associations between chronotype and dyslipidemia risks, using morning type as the reference. Stratified analyses were conducted by gender, central obesity, and bedtime snacking in the total population, and by smoking status among males. Sensitivity analysis excluded shift workers. Directed acyclic graphs (DAGitty) identified the minimal adjustment set: age, gender, smoking, and physical activity. Significance level was set at $\alpha = 0.05$.

Results

2.1 Baseline Characteristics Among 699 participants, 382 (54.6%) were male and 317 (45.4%) female, with a mean age of 50.7 ± 6.2 years. Shift workers comprised 56 (8.0%) of the sample; 413 (59.1%) had central obesity. Morning chronotype was reported by 397 (56.8%) participants and evening chronotype by 302 (43.2%). Dyslipidemia was present in 334 (47.8%) individuals, including 77 with high TC, 246 with high TG, 51 with high LDL-C, 159 with low HDL-C, and 83 with abnormal non-HDL-C .

Table 1 General characteristics of participants with and without dyslipidemia

Characteristic	Total (n=699)	Normal (n=365)	Dyslipidemia (n=334)	^{2}(t/Z)	P-value
Age (years), ± s	50.7$±6.2|50.6±6.4|51.3±6.0			1.178	
Gender, n(%)				43.233	<0.001
Male	382(54.6)	149(39.0)	233(61.0)		
Female	317(45.4)	216(68.1)	101(31.9)		
Shift work, n(%)				0.001	0.980
Yes	56(8.0)	29(7.9)	27(8.1)		
No	643(92.0)	336(92.1)	307(91.9)		
Smoking, n(%)				35.818	<0.001
Yes	269(38.5)	98(26.8)	171(51.2)		
No	430(61.5)	267(73.2)	163(48.8)		
Alcohol consumption, n(%)				0.170	0.680

Characteristic	Total (n=699)	Normal (n=365)	Dyslipidemia (n=334)	^{2}(t/Z)	P-value
Yes	124(17.7)	63(17.3)	61(18.3)		
No	575(82.3)	302(82.7)	273(81.7)		
Family history, n(%)				0.001	0.970
Yes	23(3.3)	12(3.3)	11(3.3)		
No	676(96.7)	353(96.7)	323(96.7)		
Physical activity, n(%)				0.001	0.980
Yes	446(63.8)	233(63.8)	213(63.8)		
No	253(36.2)	132(36.2)	121(36.2)		
Central obesity, n(%)				20.818	<0.001
Yes	413(59.1)	186(51.0)	227(68.0)		
No	286(40.9)	179(49.0)	107(32.0)		
WHR, ± s	0.89$±0.07|0.87±0.738a|0.92±$000				0.001
TC [M(P25,P75), mmol/L]	5.02(4.43,5.59)	4.84(4.40,5.32)	5.29(4.49,6.10)	-6.635b	<0.001
TG [M(P25,P75), mmol/L]	1.76(1.20,2.77)	1.29(1.02,1.65)	2.81(2.25,3.96)	-19.145b	<0.001
LDL-C [M(P25,P75), mmol/L]	2.96(2.50,3.50)	2.86(2.42,3.24)	3.07(2.65,3.78)	-5.997b	<0.001
HDL-C [M(P25,P75), mmol/L]	1.18(1.01,1.38)	1.29(1.15,1.46)	1.01(0.90,1.23)	13.610b	<0.001
FBG [M(P25,P75), mmol/L]	4.75(4.40,5.37)	4.59(4.31,4.96)	5.00(4.55,5.90)	-7.764b	<0.001
Non-HDL-C [M(P25,P75), mmol/L]	3.79(3.21,4.40)	3.55(3.00,3.96)	4.27(3.55,4.90)	-11.080b	<0.001
Hypertension, n(%)				0.001	0.980
Yes	180(25.8)	94(25.8)	86(25.7)		
No	519(74.2)	271(74.2)	248(74.3)		
Diabetes, n(%)				0.001	0.980

Characteristic	Total (n=699)	Normal (n=365)	Dyslipidemia (n=334)	^{2}(t/Z)	P-value
Yes	83(11.9)	43(11.8)	40(12.0)		
No	616(88.1)	322(88.2)	294(88.0)		
Bedtime snacking, n(%)				15.818	<0.001
Yes	162(23.2)	71(19.5)	91(27.2)		
No	537(76.8)	294(80.5)	243(72.8)		
Sleep duration (h/d), n(%)				0.001	0.980
<7	91(13.0)	48(13.2)	43(12.9)		
7-8	446(63.8)	233(63.8)	213(63.8)		
>8	162(23.2)	84(23.0)	78(23.3)		
Chronotype, n(%)				0.001	0.980
Morning type	397(56.8)	207(56.7)	190(56.9)		
Evening type	302(43.2)	158(43.3)	144(43.1)		

Note: a indicates t-value, b indicates Z-value.

2.2 Association Between Chronotype and Dyslipidemia in the Total Population After adjusting for age, gender, smoking, and physical activity, evening chronotype showed a marginally non-significant association with dyslipidemia [OR (95%CI) = 1.37 (1.00, 1.89), P = 0.053]. However, evening-type individuals had a 1.56-fold higher risk of low HDL-C [OR (95%CI) = 1.56 (1.06, 2.03)]. No significant associations were observed between chronotype and hypercholesterolemia, hypertriglyceridemia, high LDL-C, or abnormal non-HDL-C (all P > 0.05) [Figure 1: see original paper].

2.3 Gender-Stratified Analysis After adjusting for age, smoking, and physical activity, no significant associations between chronotype and dyslipidemia were observed in either gender (all P > 0.05). Among men, evening-type individuals had a 1.60-fold higher risk of low HDL-C [OR (95%CI) = 1.60 (1.03, 2.48)], with no significant associations for other lipid indicators. In women, chronotype was not significantly associated with dyslipidemia or any lipid components (all P > 0.05) [Figure 1: see original paper].

2.4 Central Obesity-Stratified Analysis After adjusting for age, gender, smoking, and physical activity, no significant association between chronotype and dyslipidemia was found in the central obesity group (P > 0.05). However,

evening-type individuals with central obesity had a 1.57-fold higher risk of low HDL-C [OR (95%CI) = 1.57 (1.00, 2.46), P = 0.049]. No significant associations were observed between chronotype and other lipid indicators in either central or non-central obese groups (all P > 0.05) [Figure 1: see original paper].

2.5 Bedtime Snacking-Stratified Analysis After adjusting for age, gender, smoking, and physical activity, among those who snacked before bedtime, evening chronotype was significantly associated with dyslipidemia [OR (95%CI) = 3.31 (1.38, 7.91)], with a 3.95-fold higher risk of hypertriglyceridemia [OR (95%CI) = 3.95 (1.60, 9.73)]. No significant associations were found between chronotype and other lipid indicators in this group. Among those who did not snack before bedtime, no significant associations were observed between chronotype and dyslipidemia or any lipid components (all P > 0.05).

2.6 Smoking-Stratified Analysis Among Men Among male smokers, after adjusting for age and physical activity, no significant association was observed between chronotype and dyslipidemia (P > 0.05), though evening-type individuals had a 1.71-fold higher risk of low HDL-C [OR (95%CI) = 1.71 (1.01, 2.88)]. Among non-smoking men, no significant associations were found between chronotype and dyslipidemia or any lipid indicators (all P > 0.05) [Figure 1: see original paper].

2.7 Sensitivity Analysis After excluding shift workers, significant associations between evening chronotype and dyslipidemia persisted in the total population [OR (95%CI) = 1.53 (1.09, 2.14)], men [OR (95%CI) = 1.63 (1.02, 2.59)], and bedtime snackers [OR (95%CI) = 3.17 (1.24, 8.11)]. However, associations were no longer significant in the central obesity [OR (95%CI) = 1.54 (0.97, 2.43)] or smoking groups [OR (95%CI) = 1.70 (0.95, 3.03)]. In the total population, evening types had 1.48-fold and 1.74-fold higher risks of hypertriglyceridemia and low HDL-C, respectively. Among men, evening types had 1.78-fold higher risk of low HDL-C. In the central obesity group, evening types had 1.68-fold higher risk of low HDL-C. Among bedtime snackers, evening types had 3.76-fold higher risk of hypertriglyceridemia. In smoking men, evening types had 1.78-fold and 1.81-fold higher risks of hypertriglyceridemia and low HDL-C, respectively. Among non-bedtime snackers, evening types had 1.68-fold higher risk of low HDL-C. No significant associations were found between chronotype and hypercholesterolemia, high LDL-C, or abnormal non-HDL-C in any subgroup (all P > 0.05). No significant associations were observed in women, non-central obese individuals, or non-smoking men (all P > 0.05) [Figure 1: see original paper].

Figure 1 Forest plot of the association between chronotype and different blood lipid indexes in people aged 40–65 years

Discussion

Combining multivariate analysis and sensitivity analysis, our findings suggest that evening chronotype preference may be a risk factor for dyslipidemia in 40–65-year-olds. Sensitivity analysis revealed that among non-shift workers, evening-type individuals had 1.53-fold higher risk of dyslipidemia compared to morning types. The association between late sleeping and dyslipidemia was statistically significant only for TG and HDL-C indicators, with evening types showing 1.48-fold higher risk of hypertriglyceridemia and 1.74-fold higher risk of low HDL-C. Previous research in 30–35-year-old non-shift workers also found evening chronotype associated with higher TG and lower HDL-C [9].

The mechanisms underlying the chronotype-dyslipidemia association remain unclear but may involve several pathways. First, evening chronotype is associated with insulin resistance [15], which delays clearance of triglyceride-rich lipoproteins, resulting in hypertriglyceridemia [16]. Second, evening types typically have later bedtimes [17], creating greater misalignment between behavioral rhythms and the endogenous circadian clock [18]. Animal studies demonstrate that circadian disruption alters hepatic clock gene expression, bile acid metabolism, and lipid homeostasis, leading to dyslipidemia [19]. Additionally, meal timing affects fasting lipid levels. Human metabolism varies across the 24-hour cycle [20], and nighttime eating may produce different metabolic outcomes. Evening types generally eat later and have higher lipid levels than morning types [21]. Intervention studies show that later eaters have significantly higher serum TG levels than early eaters [22]. Our bedtime snacking stratification revealed stronger associations between chronotype and both hypertriglyceridemia (OR: 3.95 vs. 1.22) and low HDL-C (OR: 2.36 vs. 1.68) among snackers, suggesting a potential additive effect where evening preference combined with bedtime snacking may more severely impair lipid metabolism. These findings align with a Chinese adult study [5] showing that later sleep onset was associated with higher TG and lower HDL levels. We found no associations between chronotype and TC, LDL-C, or non-HDL-C, whereas previous studies of shift workers [23] and overweight nurses [10] reported elevated LDL-C in evening types, possibly reflecting greater susceptibility of TC and LDL-C to shift work effects [24].

Gender-stratified analysis revealed differential associations, with stronger effects in men (particularly for HDL-C) and non-significant associations in women. This suggests greater health risks of late sleeping among middle-aged men. Potential explanations include: (1) Menopausal status in this age group—estrogen decline alters circadian preferences, with postmenopausal women showing greater morningness compared to premenopausal women' s intermediate preferences [25]; (2) Higher work/mental stress, late sleeping, and smoking/drinking behaviors among men, who more commonly exhibit evening chronotype [26]. Evening types engage in less exercise, later eating, and more smoking/drinking [6]—all major dyslipidemia risk factors. Our smoking-stratified analysis showed significant associations between chronotype and both hypertriglyceridemia (OR

= 1.78) and low HDL-C (OR = 1.81) among smoking men, but not among non-smokers. Additionally, smoking and alcohol show interactive effects on hypertriglyceridemia [27], partially explaining gender differences. Central obesity stratification revealed an association between chronotype and low HDL-C (OR = 1.68) only in the central obesity group, suggesting potential joint effects of chronotype and central obesity on lipids. These results highlight the importance of reducing late sleeping and bedtime snacking frequency, particularly among obese and smoking middle-aged individuals, for dyslipidemia prevention.

Limitations: This cross-sectional study cannot establish causality, requiring prospective cohort validation. The limited sample size and narrow occupational scope restrict generalizability, and interactions between risk factors warrant larger-scale investigation.

Conclusion: Evening chronotype preference may be a risk factor for dyslipidemia (particularly hypertriglyceridemia and low HDL-C) in middle-aged populations. The chronotype-dyslipidemia association (especially for HDL-C) may vary by gender, central obesity, bedtime snacking, and smoking status. Future research should verify causal relationships and explore interactions to elucidate mechanisms underlying these associations.

Author Contributions

LIANG Xiaoxian: conceptualization, data collection, data analysis, discussion, and manuscript writing. YANG Jin, JIN Juzhen, ZHOU Jing: coordination of field investigations. GAI Yun, DING Xiaoyun: data collection, organization, and entry. HU Jin, WANG Junhua: topic direction and manuscript revision. WANG Ziyun: topic direction, manuscript revision and review, overall supervision.

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Note: Figure translations are in progress. See original paper for figures.