

Association between Sleep Duration and Metabolic Disorders among Filipino Immigrant Women: The Filipino Women's Diet and Health Study (FiLWHEL)

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Background: Sleep plays a complex role in metabolic regulation, and the underlying linkage has not been clearly defined. We investigated the association between sleep duration and metabolic disorders in Filipino immigrants in Korea.

Methods: We analyzed 410 participants from the 2014 to 2016 baseline population of the Filipino Women's Diet and Health Study. Usual sleep duration was self-reported, and anthropometric parameters were measured directly. Blood glucose, lipid, and insulin levels were examined from fasting serum samples. We used general linear models to acquire least squares (LS) means and logistic regression models to calculate odds ratios to test the cross-sectional association between sleep duration and metabolic markers with 95% confidence intervals (CIs).

Results: We found a statistically significant linear association between increased sleep duration and elevated triglycerides, total cholesterol, and low-density lipoprotein cholesterol (LDL-C). LS means (95% CI) of <5, 5–6, 7–8, and >8 hours of sleep were 81.74 (71.43 to 93.54), 85.15 (76.65 to 94.59), 86.33 (77.84 to 95.75), and 105.22 (88.07 to 125.71), respectively, for triglycerides (*P* trend = 0.049) and 174.52 (165.02 to 184.57), 180.50 (172.79 to 188.55), 182.51 (174.83 to 190.53), and 190.16 (176.61 to 204.74), respectively, for total cholesterol (*P* trend = 0.042). For LDL-C, the LS means (95% CI) were 97.34 (88.80 to 106.71), 100.69 (93.73 to 108.18), 104.47 (97.35 to 112.10), and 109.43 (96.94 to 123.54), respectively (*P* trend = 0.047). Statistical significance persisted after additional adjustment for body mass index. The association with triglycerides was limited to current alcohol drinkers (*P* interaction = 0.048).

Conclusion: Longer sleep duration was associated with increased triglyceride, total cholesterol, and LDL-C levels. The association with triglycerides was more pronounced among moderate alcohol drinkers.

Key words: Sleep duration, Triglycerides, Cholesterol, Filipino women, Immigration

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INTRODUCTION

Sleep, a circadian pacemaker, is a principal modulator of various metabolic functions, including hormone release and glucose regu-

lation.^{1,2} Recent changes in lifestyle factors, such as increased work hours, night activities, or shift work, can reshape sleep characteristics.³ Accumulating evidence indicates that abnormal sleep duration and altered meal timing are independent risk factors for metabolic

disorders.⁴⁻⁶ Of note, sleep duration among the general public has declined concomitantly with the rise of obesity,⁷⁻⁹ which is widely known to be an indicator of metabolic disorders and has been linked to both morbidity and mortality from diabetes, several cancers, and cardiovascular disease.¹⁰⁻¹²

Numerous epidemiological studies, including meta-analyses and cohort studies, have reported an association between chronic circadian rhythm disruption and the risk of metabolic disorders, including obesity, diabetes, metabolic syndrome, and dyslipidemia.^{2,5,13-17} However, the currently available evidence contains inconsistent results about the association between sleep duration and metabolic biomarkers, particularly lipid profiles, energy storage, and the regulation of endocrine function.^{18,19} A recent meta-analysis of twelve prospective studies found a significant association between the risk of obesity and short sleep duration, but no association was found with long sleep duration.²⁰ However, no supportive evidence was found in another meta-analysis of eight articles, partly due to heterogeneity across studies and publication bias.¹⁸ Various studies have reported positive, inverse, U-shaped, and no association between habitual sleep duration and insulin resistance, with the results varying across populations and by biomarkers assessed.²¹⁻²⁵ A Korean study of 13,609 adults from the 2010 to 2012 Korean National Health and Nutrition Examination Survey found a statistically significant association between sleep duration of ≥ 9 hours and low levels of high-density lipoprotein cholesterol (HDL-C), compared with 7 hours of sleep, with an odds ratio (OR) of 1.30.²³ Hypertriglyceridemia was associated with inadequate sleep duration in a Japanese cross-sectional study.²⁶

Meanwhile, a growing migrant population is reshaping Korean society by increasing ethnic variety, which could prospectively affect the burden of disease. Among the 16,666 international marriages reported in 2022 in Korea, marriages between a foreign woman and a Korean man accounted for 72% (12,007).²⁷ The number of Filipino immigrant women married to Korean men has increased continuously and now ranks 4th in population size, following those married to men in China, Vietnam, and Japan.²⁸ Given that the physical and social well-being of immigrants is vital for both the immigrants and the host society, understanding and exploring the determinants of immigrant health status is growing in importance. A study of 287 immigrant women in Korea reported that Filipino wom-

en have the highest prevalence of obesity, compared with immigrants from China and Vietnam.²⁹ An analysis of data from the U.S. National Health Interview Survey reported that Filipinos were more likely than other Asian ethnic groups to be obese and hypertensive.³⁰ Previous studies about sleep duration examined various factors that mediate sleep behavior such as socio-demographic variables, employment, and acculturation,^{13,31,32} which suggests the need for a study that considers the heterogeneity of the immigrant population. In an analysis of Hispanic migrants in the United States, abnormal sleep duration was associated with higher odds of depression and neighborhood environment.³¹ To our knowledge, no researchers have yet taken an epidemiological approach to the association between usual sleep hours and metabolic disorders among an immigrant population in Korea. In this cross-sectional study, we used data from the Filipino Women's Diet and Health Study (FiLWHEL) to investigate the association between sleep duration and metabolic disorders, along with possible mediating factors.

METHODS

The Filipino Women's Diet and Health Study

FiLWHEL is a prospective cohort study of married Filipino immigrant women in the Republic of Korea. From March 2014 to April 2016, 504 baseline participants were recruited from throughout rural and urban areas of Korea: Seoul, Incheon, Daejeon, and rural areas of Gyeonggi and Chungcheong provinces. The participants had to meet two prerequisite conditions: aged 19 years or older and currently or previously married to a Korean man. Further details of the FiLWHEL study have been described elsewhere.³³ The three major components used for data collection were questionnaires, anthropometric measurements, and bio-specimen collection. The FiLWHEL study investigated comprehensive changes in health, social, and dietary factors among immigrant Filipino women from a long-term perspective as they adapted to Korean society. Most of the questionnaires were answered through on-site or telephone interviews. Questionnaires encompassed demographic, socioeconomic, and acculturation-related inquiries. To ensure data quality, the study was assisted by Filipino volunteers who provided clear communication in the Filipino language. Responses were immediately reviewed and verified on-site before the participants were discharged. An-

thropometric measurements such as height, weight, and waist hip circumference were collected directly on-site in accordance with the study protocol. We obtained written informed consent from all study participants. This study was approved by the Institutional Review Board of Sookmyung Women's University (SMWU-1311-BR-012).

Data collection

Of the 504 baseline participants in the FiLWHEL study, we analyzed data for 410 participants after excluding respondents who did not provide complete data for sleep hours ($n = 15$), anthropometric measurements ($n = 8$), or blood samples ($n = 11$); those who were currently pregnant ($n = 19$) or breastfeeding ($n = 56$); and those who reported an energy intake outside the plausible range ($> \pm 3$ standard deviations) ($n = 13$). Participants were further excluded during the analysis of each outcome if corresponding data were not available. As part of the questionnaire, sleep duration was assessed using the following question: "How many hours do you usually sleep each night/day (if you do night shift work)?" The respondents had four options: <5 , 5–6, 7–8, and >8 hours.

Participants' height was measured directly using a non-stretchable tape, and weight was measured directly using a digital scale or bioelectric impedance analysis machine (InBody 620; Biospace Co. Ltd). Body mass index (BMI, kg/m^2) was calculated by dividing weight in kilograms by height in meters squared. A sphygmomanometer was used to measure blood pressure, and the average of two consecutive readings was used. For blood sampling, the participants fasted for at least 8 hours, and blood was drawn by a professional phlebotomist and then immediately centrifuged and refrigerated. The serum levels of triglycerides, total cholesterol, fasting blood glucose, and HDL-C were measured using a Cobas 8000 C702-I (Roche Diagnostics). Glycosylated hemoglobin (HbA1c) levels were measured using high performance liquid chromatography principles on a Tosoh G8 (Tosoh Bioscience). Insulin levels were measured using a Cobas 8000 E602 (Roche Diagnostics) with electrochemiluminescence immunoassay methods. The intra-assay coefficient of variation for each biomarker was 1.21% to 2.79% for fasting blood glucose, 1.49% to 2.99% for total cholesterol, 1.48% to 2.33% for blood triglycerides, 0.98% to 2.11% for HDL-C, and 1.97% to 2.13% for insulin. Low-density lipoprotein cholesterol (LDL-C) was indirectly calculated via the Friedwald formula as

follows: $\text{LDL-C} = \text{total cholesterol} - \text{HDL-C} - (\text{triglycerides}/5)$.³⁴

The original homeostatic model assessment model from Matthews et al.³⁵ was applied to calculate the homeostasis model assessment of β -cell function (HOMA- β) and insulin resistance (HOMA-IR) estimates from fasting blood glucose and insulin measurements. The HOMA- β indices were calculated as follows: $20 \times \text{fasting insulin } (\mu\text{IU}/\text{mL}) / \text{fasting glucose } (\text{mmol}/\text{mL}) - 3.5$. The HOMA-IR indices were calculated as follows: $\text{fasting insulin } (\mu\text{IU}/\text{mL}) \times \text{fasting glucose } (\text{mmol}/\text{mL}) / 22.5$. Logarithmic transformation was applied to all measurements to follow the normal distribution.

Age, education level, smoking status, coffee intake, and vigorous physical activity data were obtained from structured questionnaires. Details on alcohol intake during the past year were noted. Energy intake was calculated from a single-day 24-hour recall, with portion sizes measured using food miniatures, photographs, household measures, and standard units and portions. The dietary data were computed via CAN-pro 4.0 (Computer Aided Analysis Program 4.0 for professionals; Korean Society of Nutrition). Information missing due to cultural differences was added from international resources: food composition tables from the Food and Nutrition Research Institute of the Philippines,³⁶ Korean Rural Development Administration,³⁷ and U.S. Department of Agriculture.³⁸ Overall health-related quality of life was scored using the World Health Organization Quality of Life-BREF. Alcohol consumption was derived as ethanol intake from the collective intake of soju, beer, liquor, wine, rice wine, and refined rice wine during the previous year. The ethanol intake in grams per day was calculated using the percentage of alcohol in each liquor. Metabolic syndrome criteria from the National Cholesterol Education Program Adult Treatment Panel III were used for the cut-off of each biomarker: waist circumferences ≥ 88 cm, triglycerides ≥ 150 mg/dL, HDL-C ≤ 50 mg/dL, systolic blood pressure (SBP) ≥ 130 mmHg and diastolic blood pressure (DBP) ≥ 85 mmHg (hypertension), and fasting blood glucose ≥ 100 mg/dL.³⁹ A diagnosis of metabolic syndrome was defined as the co-occurrence of three or more of those criteria.

Statistical analysis

The study population was divided into four categories corresponding to their sleep duration (<5 , 5–6, 7–8, and >8 hours). Characteristics were compared among the four categories of sleep duration

using means with standard deviations or frequencies. The nutrient residual model was applied to calculate energy-adjusted carbohydrate intake.⁴⁰ Both general linear models (GLMs) and logistic regression models were used to evaluate the association between sleep duration and serum levels of triglycerides, HDL-C, LDL-C, total cholesterol, fasting glucose, insulin, HOMA- β , HOMA-IR, BMI, waist circumference, SBP, and DBP. Least squares (LS) means with 95% confidence intervals (CIs) were calculated for each category of sleep duration using GLM procedures. The multivariable model was adjusted for education level (associate/vocational or less, college graduate or more), vigorous physical activity (yes, no), smoking (never, ever), energy intake (kcal/day, continuous), carbohydrate intake (g/day, continuous), health-related quality of life (continuous), and coffee intake (< 0.5, 0.5–< 2, $\geq$ 2 cups/day). We additionally adjusted for BMI ($\leq$ 23, 23–25, $>$ 25 kg/m²), a possible intermediate factor, in the further multivariable model for the lipid

and insulin resistance analyses. We conducted pairwise *post hoc* testing for each category of sleep duration using the contrast statement and Tukey multiple comparison test. A logistic regression model was applied to generate ORs and 95% CIs and included the same covariates used for the GLM in each model. Tests for trends were performed using an ordinal variable for sleep duration.

The other covariates under consideration were menopausal status (yes, no), nap time (minutes, continuous), and length of residence in Korea (years, continuous), but including them in the model did not significantly change the associations; therefore, those covariates were not included in the final model. An interaction analysis was performed using the Wald-test of the cross-product term. We further examined whether the association between sleep duration and circulating triglyceride levels varied by age ($\leq$ median or $>$ median), BMI ($<$ 25, $\geq$ 25 kg/m²), energy intake ($\leq$ median or $>$ median), current alcohol drinking status (yes, no), and smoking status

Table 1. Characteristics of the study participants according to sleep duration in the FILWHEL study

Characteristic	Usual sleep duration (hr/day)				<i>P</i> *
	<5	5–6	7–8	>8	
No. of participants	64	150	162	34	
Age (yr)	36.11 $\pm$ 8.32	35.47 $\pm$ 7.73	34.67 $\pm$ 7.77	35.26 $\pm$ 9.26	0.777
Body mass index (kg/m ²)	23.67 $\pm$ 4.15	24.19 $\pm$ 4.04	23.27 $\pm$ 3.81	23.07 $\pm$ 3.05	0.332
Energy (kcal/day)	1,774.66 $\pm$ 643.23	1,719.31 $\pm$ 598.76	1,737.74 $\pm$ 669.81	1,682.81 $\pm$ 767.66	0.672
Fasting glucose (mg/dL)	89.25 $\pm$ 12.44	89.17 $\pm$ 11.78	87.65 $\pm$ 10.86	90.25 $\pm$ 15.31	0.502
Alcohol intake (g/day)	1.69 $\pm$ 4.28	1.79 $\pm$ 5.15	1.14 $\pm$ 2.30	4.03 $\pm$ 16.02	0.174
Length of residence (yr)	9.44 $\pm$ 5.44	8.86 $\pm$ 5.10	8.13 $\pm$ 5.45	7.35 $\pm$ 5.42	0.295
Education					0.836
High school graduate or less	17 (26.56)	51 (34.00)	51 (31.48)	9 (26.47)	
Associate vocational	8 (12.50)	20 (13.33)	16 (9.88)	4 (11.76)	
College graduate or more	39 (60.94)	79 (52.67)	95 (58.64)	21 (61.76)	
Smoking status					0.825
Never	57 (89.06)	136 (90.67)	149 (91.98)	32 (94.12)	
Ever	7 (10.94)	14 (9.33)	13 (8.02)	2 (5.88)	
Coffee intake					0.476
None	10 (15.63)	21 (14)	21 (12.96)	8 (23.53)	
0 < to < 2 cup/day	32 (50.00)	67 (44.67)	86 (53.09)	18 (52.94)	
2+ cups/day	22 (34.38)	62 (41.33)	55 (33.95)	8 (23.53)	
Triglycerides (mg/dL)	76.72 $\pm$ 1.57	78.48 $\pm$ 1.61	77.84 $\pm$ 1.55	93.56 $\pm$ 1.78	0.200
Total cholesterol (mg/dL)	172.75 $\pm$ 1.22	176.65 $\pm$ 1.25	176.79 $\pm$ 1.19	183.01 $\pm$ 1.23	0.608
LDL-C (mg/dL)	95.86 $\pm$ 1.37	98.58 $\pm$ 1.45	100.85 $\pm$ 1.31	104.47 $\pm$ 1.35	0.564
HDL-C (mg/dL)	57.23 $\pm$ 1.25	56.46 $\pm$ 1.29	56.48 $\pm$ 1.25	54.00 $\pm$ 1.28	0.722
Insulin (μ U/mL)	7.65 $\pm$ 1.92	8.21 $\pm$ 2.07	7.53 $\pm$ 1.75	8.80 $\pm$ 1.81	0.480

Values are presented as mean $\pm$ standard deviation or number (%).

*Mean $\pm$ standard deviation for continuous variables and analysis of variance for *P*-value, number (%) for categorical variables and chi-squared test for *P*-value.

FILWHEL, Filipino Women's Diet and Health Study; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

(never, ever). All analyses were conducted in SAS version 9.4 (SAS Institute Inc.). All statistical tests were two-sided, and *P*-values less than 0.05 were considered statistically significant.

RESULTS

From the 504 baseline participants of the FiLWHEL study, we analyzed 410 participants for the blood pressure analysis, 404 participants for the obesity analysis, and 401 participants for the lipid profile and insulin resistance analyses. The baseline characteristics of the 410 study participants are presented in Table 1 according to their habitual sleep duration. Compared with individuals with the shortest sleep duration, those with the longest sleep duration were slightly younger, had higher but moderate alcohol intake, greater levels of LDL-C, and had stayed for a shorter duration in Korea. Those with > 8 hours of sleep duration were less likely to have ever smoked or drink coffee than those with < 5 hours of sleep duration.

We found that increasing sleep duration was associated with circulating levels of blood triglycerides, total cholesterol, and LDL-C

(Table 2). The LS means for < 5, 5–6, 7–8, and > 8 hours of sleep were as follows: for triglycerides, 81.74 mg/dL (95% CI, 71.43 to 93.54), 85.15 mg/dL (95% CI, 76.65 to 94.59), 86.33 mg/dL (95% CI, 77.84 to 95.75), and 105.22 mg/dL (95% CI, 88.07 to 125.71), respectively (*P* trend = 0.049); for total cholesterol, 174.52 mg/dL (95% CI, 165.02 to 184.57), 180.50 mg/dL (95% CI, 172.79 to 188.55), 182.51 mg/dL (95% CI, 174.83 to 190.53), and 190.16 mg/dL (95% CI, 176.61 to 204.74), respectively (*P* trend = 0.042); and for LDL-C 97.34 mg/dL (95% CI, 88.80 to 106.71), 100.69 mg/dL (95% CI, 93.73 to 108.18), 104.47 mg/dL (95% CI, 97.35 to 112.10), and 109.43 mg/dL (95% CI, 96.94 to 123.54), respectively (*P* trend = 0.047). Tukey's *post hoc* analysis was significant at the *P* < 0.05 level for the multiple comparison between mean triglyceride levels with > 8 hours of sleep and each of the other categories of sleep duration. The multiple comparison between the mean total cholesterol with > 8 hours of sleep and < 5 hours of sleep was also significant.

When we additionally adjusted for BMI, the association remained significant for triglyceride and total cholesterol levels. The LS means

Table 2. Least squares means (95% confidence intervals) for anthropometric measures and circulating levels of triglycerides and cholesterol according to sleep duration in the FiLWHEL study

Variable	LS means (95% CIs) (hr/day)				<i>P</i> trend	<i>Post hoc</i> *
	<5	5–6	7–8	>8		
BMI (kg/m ²)						
Multivariate adjusted [†]	24.21 (23.13–25.34)	24.80 (23.94–25.69)	24.09 (23.26–24.96)	24.13 (22.75–25.60)	0.442	
Waist circumference (cm)						
Multivariate adjusted [†]	81.23 (78.62–83.93)	81.65 (79.61–83.74)	80.69 (78.68–82.75)	82.88 (79.44–86.47)	0.941	
Triglycerides (mg/dL)						
Multivariate adjusted [†]	81.74 (71.43–93.54)	85.15 (76.65–94.59)	86.33 (77.84–95.75)	105.22 (88.07–125.71)	0.049	a-d, b-d, c-d
Multivariate adjusted [‡]	81.75 (71.68–93.25)	83.59 (75.48–92.56)	86.74 (78.49–95.86)	102.26 (86.12–121.42)	0.040	a-d, b-d
Total cholesterol (mg/dL)						
Multivariate adjusted [†]	174.52 (165.02–184.57)	180.50 (172.79–188.55)	182.51 (174.83–190.53)	190.16 (176.61–204.74)	0.042	a-d
Multivariate adjusted [‡]	174.67 (165.10–184.78)	179.69 (172.02–187.71)	182.51 (174.87–190.48)	188.59 (175.23–202.98)	0.049	
HDL-C (mg/dL)						
Multivariate adjusted [†]	55.59 (51.87–59.58)	55.60 (52.68–58.69)	55.79 (52.90–58.84)	53.40 (48.73–58.52)	0.675	
Multivariate adjusted [‡]	55.69 (52.01–59.64)	56.13 (53.23–59.19)	55.73 (52.91–58.71)	54.16 (49.53–59.22)	0.648	
LDL-C (mg/dL)						
Multivariate adjusted [†]	97.34 (88.80–106.71)	100.69 (93.73–108.18)	104.47 (97.35–112.10)	109.43 (96.94–123.54)	0.047	
Multivariate adjusted [‡]	97.41 (88.88–106.75)	99.79 (92.95–107.13)	104.45 (97.43–111.98)	107.62 (95.49–121.29)	0.053	

*Tukey's multiple comparison analyses assessed significant pairwise differences between < 5 (a), 5–6 (b), 7–8 (c), > 8 hr/day (d) at the *P* < 0.05 level; [†]Models were adjusted for age (years, continuous), education (associate vocational or less, college graduate or more), vigorous activity (yes, no), smoking (never, ever), health-related quality of life (continuous), coffee intake (< 0.5, 0.5–< 2, ≥ 2 cups/day), carbohydrate intake (g/day, continuous), and energy intake (kcal/day, continuous); [‡]Models were additionally adjusted for BMI (≤ 23, 23–< 25, ≥ 25 kg/m²).

FiLWHEL, Filipino Women's Diet and Health Study; LS, least square; CI, confidence interval; BMI, body mass index; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

for < 5, 5–6, 7–8, and > 8 hours of sleep were as follows: for triglycerides, 81.75 mg/dL (95% CI, 71.68 to 93.25), 83.59 mg/dL (95% CI, 75.48 to 92.56), 86.74 mg/dL (95% CI, 78.49 to 95.86), and 102.26 mg/dL (95% CI, 86.12 to 121.42), respectively (P trend = 0.040) and for total cholesterol 174.67 mg/dL (95% CI, 165.10 to 184.78), 179.69 mg/dL (95% CI, 172.02 to 187.71), 182.51 mg/dL (95% CI, 174.87 to 190.48), and 188.59 mg/dL (95% CI, 175.23 to 202.98), respectively (P trend = 0.049). We did not observe any significant associations between sleep duration and BMI, waist circumference, HDL-C, fasting glucose, HbA1c, insulin, HOMA-IR, HOMA- β , SBP, or DBP (Tables 2 and 3). A similar trend was observed after additionally adjusting for blood pressure, alcohol intake, and fasting glucose (Supplementary Table 1) or excluding participants who consumed more than 20 g of alcohol per day (Supplementary Table 2). The association was also maintained after ex-

cluding participants who were taking medications or previously diagnosed with hyperlipidemia or diabetes (Supplementary Table 3).

Participants with > 8 hours sleep duration had 4.47 times higher odds (95% CI, 1.52 to 13.21; P trend = 0.033) of high triglycerides than participants who slept for 7–8 hours per night (Table 4). We further conducted a subgroup analysis for circulating levels of triglycerides and total cholesterol (Table 5). The positive association with triglyceride levels was more pronounced in alcohol drinkers than in non-drinkers (P interaction = 0.048). No significant interactions were found for total cholesterol.

DISCUSSION

In this study, long sleep duration was associated with increased serum triglycerides, total cholesterol, and LDL-C levels among Fili-

Table 3. Least squares means (95% confidence intervals) for circulating levels of fasting glucose, insulin resistance markers and blood pressure according to sleep duration in the FILWHEL study

Variable	LS means (95% CIs) (hr/day)				<i>P</i> trend	<i>Post hoc</i> *
	<5	5–6	7–8	>8		
Fasting glucose (mg/dL)						
Multivariate adjusted†	88.46 (85.48–91.55)	88.60 (86.26–91.01)	87.19 (84.92–89.51)	89.44 (85.48–93.58)	0.647	
Multivariate adjusted‡	88.41 (85.39–91.54)	88.44 (86.09–90.85)	87.18 (84.91–89.52)	89.11 (85.15–93.25)	0.639	
HbA1c (%)						
Multivariate adjusted†	5.46 (5.32–5.61)	5.58 (5.47–5.70)	5.46 (5.35–5.57)	5.42 (5.23–5.61)	0.282	b-c
Multivariate adjusted‡	5.46 (5.31–5.60)	5.57 (5.46–5.69)	5.46 (5.36–5.57)	5.40 (5.22–5.59)	0.283	
Insulin (μU/mL)						
Multivariate adjusted†	8.68 (7.19–10.47)	9.25 (7.99–10.71)	8.68 (7.52–10.03)	10.71 (8.36–13.73)	0.524	
Multivariate adjusted‡	8.60 (7.25–10.19)	8.97 (7.86–10.23)	8.76 (7.70–9.97)	10.09 (8.08–12.60)	0.446	
HOMA-IR						
Multivariate adjusted†	1.89 (1.54–2.32)	2.02 (1.72–2.37)	1.87 (1.60–2.18)	2.36 (1.81–3.09)	0.610	
Multivariate adjusted‡	1.87 (1.56–2.26)	1.96 (1.69–2.26)	1.88 (1.64–2.17)	2.22 (1.74–2.83)	0.544	
HOMA-β						
Multivariate adjusted†	130.47 (108.76–156.52)	139.14 (120.73–160.36)	137.20 (119.31–157.78)	155.63 (122.40–197.89)	0.348	
Multivariate adjusted‡	129.74 (109.51–153.70)	135.76 (119.04–154.83)	138.51 (121.77–157.55)	148.38 (118.92–185.14)	0.289	
SBP (mmHg)						
Multivariate adjusted†	114.81 (110.72–119.05)	122.34 (118.94–125.83)	117.95 (114.70–121.30)	118.01 (112.57–123.71)	0.930	a-b, b-c
Multivariate adjusted‡	115.26 (111.30–119.37)	121.99 (118.76–125.31)	118.15 (115.06–121.33)	117.51 (112.37–122.89)	0.956	a-b
DBP (mmHg)						
Multivariate adjusted†	73.14 (70.16–76.25)	78.24 (75.76–80.81)	75.98 (73.58–78.46)	76.34 (72.32–80.59)	0.464	a-b
Multivariate adjusted‡	74.89 (72.30–77.57)	78.29 (76.02–80.43)	76.5 (74.49–78.57)	76.36 (73.01–79.87)	0.876	a-b

*Tukey's multiple comparison analyses assessed significant pairwise differences between < 5 (a), 5–6 (b), 7–8 (c), > 8 hr/day (d) at the $P < 0.05$ level; [†]Models were adjusted for age (years, continuous), education (associate vocational or less, college graduate or more), vigorous activity (yes, no), smoking (never, ever), health-related quality of life (continuous), coffee intake (< 0.5, 0.5–< 2, ≥ 2 cups/day), carbohydrate intake (g/day, continuous), and energy intake (kcal/day, continuous); [‡]Models were additionally adjusted for body mass index (≤ 23 , $23 < 25$, ≥ 25 kg/m²).

FILWHEL, Filipino Women's Diet and Health Study; LS, least square; CI, confidence interval; HbA1c, glycosylated hemoglobin; HOMA-IR, homeostasis model assessment of insulin resistance; HOMA- β , homeostasis model assessment of β -cell function; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 4. Odds ratios (95% confidence interval) for metabolic syndrome and its components according to sleep duration in the FILWHEL study

Variable	Odds ratios (95% CIs) (hr/day)				P trend
	<5	5–6	7–8	>8	
Waist circumferences (≥ 88 cm)					
No. of cases/total	9/61	26/142	26/157	4/32	
Multivariate adjusted*	0.62 (0.26–1.49)	0.98 (0.52–1.82)	1	0.84 (0.26–2.70)	0.480
Fasting glucose (> 110 mg/dL)					
No. of cases/total	8/61	18/142	11/157	5/32	
Multivariate adjusted*	1.68 (0.59–4.77)	1.91 (0.83–4.39)	1	2.12 (0.62–7.21)	0.563
HDL-C (< 50 mg/dL)					
No. of cases/total	13/61	41/142	40/157	13/32	
Multivariate adjusted*	0.90 (0.43–1.87)	1.24 (0.73–2.09)	1	1.97 (0.87–4.49)	0.404
Triglycerides (≥ 150 mg/dL)					
No. of cases/total	4/61	14/142	13/157	8/32	
Multivariate adjusted*	0.66 (0.19–2.26)	1.11 (0.48–2.58)	1	4.47 (1.52–13.21)	0.033
High blood pressure†					
No. of cases/total	8/61	53/142	35/157	7/32	
Multivariate adjusted*	0.37 (0.14–0.97)	2.28 (1.26–4.12)	1	1.02 (0.34–3.06)	0.682
Metabolic syndrome‡					
No. of cases/total	3/61	18/142	10/157	3/32	
Multivariate adjusted*	0.58 (0.14–2.33)	2.11 (0.90–4.95)	1	1.43 (0.33–6.22)	0.884

*Models were adjusted for age (years, continuous), education (associate vocational or less, college graduate or more), vigorous activity (yes, no), smoking (never, ever), health-related quality of life (continuous), coffee intake (< 0.5 , 0.5 – < 2 , ≥ 2 cups/day), carbohydrate intake (g/day, continuous), and energy intake (kcal/day, continuous); [†]High blood pressure was defined as systolic blood pressure ≥ 130 mmHg, or diastolic blood pressure ≥ 85 mmHg; [‡]Metabolic syndrome was defined as the co-existence of three or more of the following five criteria from the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III): waist circumferences ≥ 88 cm, HDL-C ≤ 50 mg/dL, triglycerides ≥ 150 mg/dL, systolic blood pressure ≥ 130 mmHg, and diastolic blood pressure ≥ 85 mmHg (hypertension), and fasting blood glucose ≥ 100 mg/dL.

FILWHEL, Filipino Women's Diet and Health Study; CI, confidence interval; HDL-C, high-density lipoprotein cholesterol.

pino women in Korea. These associations were independent of age, BMI, smoking status, alcohol drinking, health-related quality of life, education, and coffee intake. However, we did not observe any significant associations between sleep duration and obesity, insulin resistance markers, or blood pressure.

Several longitudinal and cross-sectional studies reported that sleep curtailment or surplus was associated with an increased risk of obesity,^{41,42} insulin resistance,^{43,44} or metabolic syndrome.^{5,45,46} Our study finding is consistent with a few epidemiologic studies reporting that increased sleep duration is associated with an elevated risk of metabolic disorder biomarkers. The U.S. Multiethnic Cohort Study²¹ and Chinese Guangzhou Biobank Cohort Study⁴⁷ observed that sleep duration was positively associated with circulating levels of triglycerides. Meanwhile, a U-shaped association between sleep duration and triglyceride levels was reported in Japanese^{24,26} and Chinese studies.⁴⁸ Several studies found no association between sleep duration and triglyceride levels.^{22,25,49} As for circulating levels of cholesterol, the Coronary Artery Risk Development in Young

Adults Sleep study²³ and the Rotterdam study⁵⁰ reported that long sleep duration was associated with increased levels of total cholesterol, whereas other studies found an inverse^{25,51} or null association.²² A few studies reported mixed results regarding the relationship between HDL-C or LDL-C and sleep duration. Low^{21,22,25,26} or similar HDL-C levels⁴¹ were found with long sleep duration, compared with short or normal sleep duration, and low^{26,42} or similar^{22,25,49} LDL-C levels were also found with long sleep duration, compared with short or normal sleep duration, in cross-sectional and prospective studies.

Our study showed discrepant findings with regard to obesity and insulin resistance, although the reasons are unclear. For blood pressure, a recent meta-analysis showed that short sleep duration was associated with hypertension.^{45,46,52} However, in our study, participants with < 5 hours of sleep duration had lower blood pressures than those in the upper categories of sleep duration. Although we did not find a significant association with obesity, our results might suggest a potential link to metabolic syndrome.

Table 5. Least squares means and 95% confidence intervals for circulating levels of triglycerides and cholesterol according to sleep duration and other factors in the FILWHEL study

Variable	LS means (95% CI) (hr/day)*				P trend	P interaction
	<5	5–6	6–7	>8		
Triglycerides (mg/dL)						
Age (yr) [†]						0.244
≤ 33 (n=189)	73.74 (60.47–89.92)	80.74 (70.03–93.09)	81.25 (71.16–92.76)	96.90 (76.16–123.28)	0.124	
> 33 (n=212)	87.61 (71.87–106.81)	89.06 (75.10–105.62)	88.48 (73.81–106.06)	114.79 (86.81–151.79)	0.242	
BMI (kg/m ²)						0.182
< 25 (n=282)	71.81 (61.02–84.51)	71.63 (62.63–81.92)	79.15 (70.07–89.41)	92.65 (74.78–114.80)	0.016	
≥ 25 (n=119)	100.28 (78.65–127.87)	109.17 (91.51–130.24)	98.45 (79.47–121.96)	117.72 (85.56–161.97)	0.822	
Energy (kcal) [‡]						0.328
≤ 1,635 (n=199)	85.93 (70.35–104.96)	78.81 (68.17–91.12)	86.14 (75.01–98.92)	101.92 (81.84–126.93)	0.156	
> 1,635 (n=202)	79.14 (65.33–95.87)	92.12 (78.55–108.03)	86.75 (74.00–101.70)	111.40 (82.39–150.62)	0.164	
Current alcohol drinker						0.048
Yes (n=157)	72.81 (61.60–86.05)	82.96 (73.10–94.15)	83.03 (73.15–94.26)	106.24 (84.02–134.33)	0.025	
No (n=244)	105.59 (78.72–141.63)	93.84 (73.10–120.47)	96.63 (76.20–122.53)	113.83 (81.75–158.49)	0.797	
Ever smoker [‡]						0.212
Yes (n=36)	74.34 (65.45–84.43)	74.24 (67.98–81.08)	77.16 (71.07–83.76)	90.73 (76.92–107.02)	0.081	
No (n=365)	77.83 (50.39–120.21)	90.32 (64.43–126.61)	91.50 (66.12–126.62)	110.24 (50.05–242.80)	0.447	
Total cholesterol (mg/dL)						
Age (yr) [†]						0.425
≤ 33 (n=189)	164.68 (151.96–178.46)	171.80 (162.18–182.00)	174.88 (165.74–184.53)	180.79 (163.98–199.30)	0.097	
> 33 (n=212)	180.88 (166.15–196.92)	183.22 (170.30–197.11)	182.67 (169.01–197.44)	196.69 (174.48–221.72)	0.364	
BMI (kg/m ²)						0.672
< 25 (n=282)	173.87 (161.98–186.63)	177.65 (167.57–188.33)	183.60 (174.11–193.59)	187.57 (170.87–205.90)	0.404	
≥ 25 (n=119)	174.37 (158.44–191.90)	185.89 (173.40–199.28)	177.86 (163.46–193.52)	191.09 (168.50–216.70)	0.542	
Energy (kcal) [‡]						0.937
≤ 1,635 (n=199)	187.18 (172.15–203.53)	186.60 (175.60–198.27)	188.73 (178.12–199.98)	192.07 (175.21–210.54)	0.329	
> 1,635 (n=202)	167.12 (154.47–180.82)	176.61 (165.43–188.56)	176.91 (165.73–188.85)	186.53 (164.79–211.13)	0.107	
Current alcohol drinker						0.930
Yes (n=157)	177.94 (166.28–190.42)	180.07 (171.07–189.55)	179.74 (170.74–189.22)	190.56 (173.27–209.58)	0.390	
No (n=244)	165.67 (145.53–188.60)	177.98 (159.40–198.72)	182.72 (164.54–202.91)	187.24 (161.79–216.70)	0.032	
Ever smoker [‡]						0.821
Yes (n=36)	166.71 (157.86–176.07)	171.82 (165.45–178.43)	175.00 (168.94–181.27)	177.34 (165.23–190.35)	0.081	
No (n=365)	183.11 (153.77–218.04)	198.79 (173.56–227.67)	171.15 (150.21–195.00)	236.97 (172.57–325.41)	0.928	

*Models were adjusted for age (years, continuous), education (associate vocational or less, college graduate or more), vigorous activity (yes, no), smoking (never, ever), health-related quality of life (continuous), coffee intake (<0.5, 0.5–<2, ≥2 cups/day), carbohydrate intake (g/day, continuous), and energy intake (kcal/day, continuous); [†]Continuous variables were dichotomized based on median values; [‡]Models were adjusted for age (years, continuous), education (associate vocational or less, college graduate or more), vigorous activity (yes, no), health-related quality of life (continuous), coffee intake (<0.5, 0.5–<2, ≥2 cups/day), carbohydrate intake (g/day, continuous), and energy intake (kcal/day, continuous). FILWHEL, Filipino Women's Diet and Health Study; LS, least square; CI, confidence interval; BMI, body mass index.

Our results further suggest that the association with triglyceride levels could vary by alcohol drinking status. Alcohol drinking elevates triglyceride levels, so ethanol intake might modify the association between sleep duration and triglyceride levels. However, the alcohol consumption of the Filipino participants was modest in quantity, and the association was maintained after adjusting for alcohol intake. In the stratified analysis, a more pronounced associa-

tion was found for current drinkers than non-drinkers. Given that more than 90% of the drinking population consumed less than 20 g of alcohol per day, moderate alcohol intake among the study participants was correlated with lower triglyceride levels in our results. That finding aligns with previous epidemiologic studies, including the Copenhagen City Heart study, which reported a J-shaped association between alcohol intake and triglycerides in women.⁵³ A re-

cent Mendelian randomization study also reported an association between moderate alcohol consumption and lower triglyceridemia.⁵⁴ The inconsistent results from current and previous research suggests the need for further investigation of this potential interaction with moderate and heavy alcohol drinking in multiple populations.

Although the underlying mechanism between short sleep duration and the risk of metabolic disorders has been suggested to be linked to the appetite regulation of leptin and ghrelin, appetite suppressor and stimulant hormones, respectively,⁵⁵⁻⁵⁷ the etiology behind the association between long sleep duration and an abnormal metabolic pathway is relatively unknown. Excessive sleep duration could decrease myokine production, impair the phase coherence between circadian regulation and behavioral rhythms such as meal timing, and increase sedentary behavior and physical inactivity. Such behavioral and hormonal changes could result in decreased glucose effectiveness, systemic insulin sensitivity, and synthesis of the satiety-enhancing factor glucagon-like peptide-1 and result in a higher risk of obesity and type 2 diabetes mellitus.⁵⁸ Of note, recent studies have suggested a bidirectional relationship among metabolic disorders with a positive feedback cycle that enhances abnormal sleep duration.^{3,58}

The strength of our findings is that this is the first study, to our knowledge, to examine the relationship between sleep duration and metabolic abnormalities among Filipino women in Korea. In addition, the study data collection process was standardized, and sample processing was centralized. However, the following limitations should be considered. First, the cross-sectional nature of the study precludes the imputation of causality for our findings. Second, sleep duration was self-reported and not determined by objective polysomnography, and thus, the responses could be subject to some degree of error. However, measurement error is likely to be non-differential with respect to recall of sleep duration and metabolic biomarker assessments. The study sample could have limited statistical power due to the small sample size; however, significant associations with triglycerides and cholesterol were identified. Lastly, although we adjusted for confounding factors, we cannot completely rule out the existence of potential residual or unmeasured confounding.

In conclusion, an increase in usual sleep duration was associated with elevated blood triglyceride and total cholesterol levels in Fili-

pino immigrant women in Korea. Although sleep exposes complex relationships with the circadian rhythm, the underlying pathology underlying the association with metabolic risk factors still needs to be investigated for health promotion and disease prevention. Further prospective and experimental studies are warranted to understand the potential mechanisms that underlie the association between sleep duration and blood triglyceride and cholesterol levels.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found online at <https://doi.org/10.7570/jomes22032>.

CONFLICTS OF INTEREST

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AUTHOR CONTRIBUTIONS

Study concept and design: GHC, SH, SHY, JEL, and CBL; acquisition of data: HSK, HL, SMPP, SH, SHY, JEL, and CBL; analysis and interpretation of data: HSK, HL, SMPP, and JEL; drafting of the manuscript: HSK, HL, and JEL; critical revision of the manuscript: HSK, HL, SMPP, GHC, SH, SHY, JEL, and CBL; statistical analysis: HSK; obtained funding: JEL and CBL; administrative, technical, or material support: GHC, SH, SHY, JEL, and CBL; and study supervision: JEL and CBL.

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