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Behavioral Characteristics and Cardiovascular Disease Risks Associated With Insomnia and Sleep Quality Among Middle-Aged Women in South Korea

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Abstract: Insomnia is the most common sleep problem in women. Increasing evidence suggests an association between insomnia and cardiovascular disease (CVD). However, information is limited on lifestyle and socio-environmental factors associated with sleep problems in women. In this study directed by Social Cognitive Theory, we examined the personal, behavioral, socio-environmental, and CVD risk factors associated with sleep characteristics (insomnia and sleep quality) in middle-aged women using a cross-sectional design. The study instruments included the Insomnia Severity Index (ISI), the Pittsburg Sleep Quality Index (PSQI), the Center for Epidemiological Studies Depression Scale (CES-D), and measures of social support and behavioral characteristics. Blood was drawn to assess serum glucose and lipids, and BMI was measured. Data were analyzed using hierarchical multiple regression and analysis of covariance (ANCOVA). Of 423 middle-aged women, 25% experienced insomnia (ISI $\geq$ 10) and 41.3% reported poor sleep quality (PSQI $\geq$ 5). Lesser education ($\leq$middle school), more depressive symptoms, more screen time ($\geq$ 3 hours/day), and severe stress were associated with greater severity of insomnia and/or poorer sleep quality. Total and LDL cholesterol levels were higher in women with insomnia than normal sleepers, whereas the BMI was higher in those who reported poor sleep quality. Because personal, behavioral, and socio-environmental factors were significantly associated with insomnia and poor sleep quality, multifactorial approaches should be considered in developing sleep interventions and reducing cardiovascular risk.

Keywords: insomnia; sleep quality; depression; cardiovascular risk
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Insomnia is the most common sleep problem in women, affecting 42% of midlife women (Cho, 2002) and 54% of post-menopausal women (Timur & Sahin, 2009). Hormones and gender-specific responses to environmental stress may make women more vulnerable to poor sleep (Hung et al., 2013). A broad clinical definition of insomnia includes wakefulness or perception of disturbed sleep. Individuals with insomnia have difficulty in falling asleep and staying asleep.

Increasing evidence suggests that chronic insomnia may increase anxiety, depressive symptoms, and obesity and decrease the quality of life (Taylor et al., 2014; Wolk & Somers, 2007). In a population-based study, insomnia was associated with an increased risk of hypertension and cardiovascular disease (CVD; Quan, 2009). The underlying mechanism of the relationship between insomnia and CVD risk is unclear, but disrupted sleep may increase sympathetic nervous system activity and catecholamine secretion, which in turn increases the risk of hypertension and coronary artery disease (Nagai, Hoshide, & Kario, 2010).

In studies of the factors associated with insomnia and sleep quality in women, Timur and Sahin (2009) found that peri-menopausal status, physical illness, and depression raised the risk of sleep disturbance. Others found that insomniacs had dysfunctional beliefs about sleep and sleep hygiene (Tsai et al., 2013). Educational attainment, stress, and sedentary lifestyle were significantly associated with insomnia and poor sleep quality (Cuadros et al., 2012; Grandner et al., 2010; Madden, Ashe, Lockhart, & Chase, 2014). Hormonal alterations, such as hypercortisolemia, may explain the associations among stress, depression, and insomnia (Hasler, 2010). However, few teams have studied insomnia and sleep quality and related cardiovascular health status, especially in middle-aged women, and comprehensive assessments within a theoretical framework are rare. Understanding the risk factors associated with insomnia and sleep quality and resulting health problems will enable effective interventions to alleviate sleep problems among middle-aged women.

We recruited women aged 40–65 years and examined the factors associated with insomnia and sleep quality among middle-aged women. We defined middle-aged as between 40 and 65 years old, drawing from a team of Korean researchers who evaluated the effects of aromatherapy on stress and depression in women aged 37–65 years, defining them as middle-aged (Kim, Song, Kim, & Hur, 2016). Others also investigated the successful aging of middle-aged women targeting women aged 40–65 years (Lee & Yang, 2012).

Applying Social Cognitive Theory to Insomnia

Social Cognitive Theory posits reciprocal bidirectional relationships among personal, behavioral, and environmental factors in determining human behavior, which could be interpreted as reciprocal determinism (Bandura, 1997; McAlister, Perry, & Parcel, 2008). The products of these bidirectional interactions determine life paths and affect life courses, which may include biological functions and health (Bandura, 1989, 1997).

Social Cognitive Theory has been applied to alcohol abuse, smoking cessation, and AIDS prevention programs (McAlister et al., 2008), but not to insomnia. Spielman's 3P model, which posits that three types of factors are involved in developing insomnia including predisposing (e.g., anxiety and hyperarousal), precipitating (e.g., illness and stress), and perpetuating factors (e.g., extended time in bed and naps), is the most widely utilized model of insomnia (Spielman, Caruso, & Glovinsky, 1987). Based on Social Cognitive Theory, we considered a wider set of factors in relation to insomnia and sleep quality. The aim of this study was to explore the personal (demographic characteristics, menopausal status, and depressive symptoms), behavioral (exercise, screen time, alcohol consumption, coffee intake, and eating behavior), and socio-environmental (stress and social support) factors associated with sleep characteristics (insomnia and sleep quality), and to determine whether there were impacts of these interactions on the CVD risk factors of middle-aged women (Fig. 1).

Methods

Sample and Setting

This study used a cross-sectional non-experimental design. The study participants were recruited in a community setting in one metropolitan city area in South Korea. Fliers, banners, and local newspapers were used to recruit the study participants. Potential participants contacted the research team members using the telephone numbers appearing on the promotional media, and they were screened for eligibility before data collection.

The eligibility criteria included women aged between 40 and 65 years who could read and write the Korean language, and who understood the purpose of the study. Women with mental health problems other than insomnia, with obstructive sleep apnea, who were using sleeping pills,

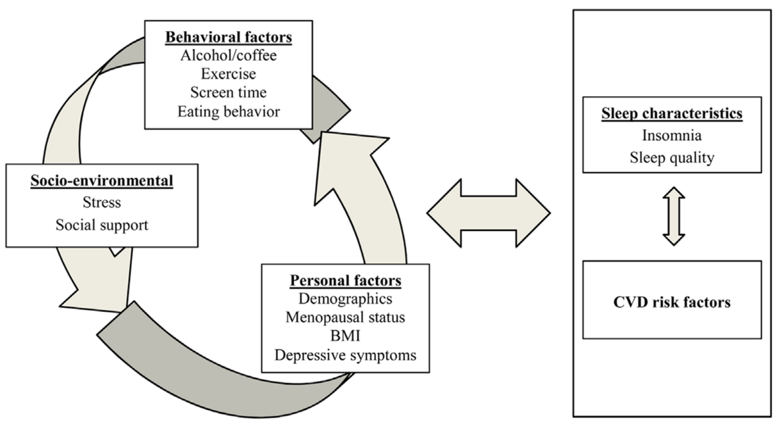

Figure 1. Social Cognitive Theory applied to insomnia. BMI = body mass index, CVD = cardiovascular disease.

and who underwent cancer therapy were excluded. Four hundred and twenty-five women participated voluntarily in the study. However, two questionnaires were excluded due to incomplete answers, leaving 423 women in the analysis.

Ethical Considerations

This study was approved by the institutional review board of the university with which the authors were affiliated. Data were collected after obtaining written consent from the participants. Informed consent forms explained that they could withdraw from the study without penalty. Anonymity and confidentiality were maintained throughout the study. Survey materials with written consent forms were stored in a locked file cabinet located in the first author's office.

Measures

Personal, behavioral, socio-environmental, and sleep characteristics were self-reported by the study participants using a standard protocol. Data for a CVD risk profile (body mass index [BMI], waist circumference, blood pressure, glucose, and lipid profile) were collected using biometric measures and serum samples.

Personal characteristics. Information on the subjects' age, income, education, marital status, and employment were collected by questionnaire because these demographic characteristics were identified as having significant relationships with sleep problems in earlier studies (Cho, 2002; Cuadros et al., 2012; Cunningham, Ford, Chapman, Liu, & Croft, 2015; Grandner et al., 2010). The participants were asked to provide their age in years and monthly family income in Korean won (₩) (1,000 won $=$ $1.00 USD). Education ($\leq$elementary, middle, high school, or $\geq$college), marital status (single, married/ cohabiting, or widowed/divorced), and employment status (yes or no) were measured as categorical variables. Menopausal status was measured with questions recommended by the World Health Organization (WHO; WHO Scientific Group, 1996). Women who had a regular cycle and amount of menstruation in the previous 3 months were categorized as pre-menopausal. Women who had menses in the previous 12 months but experienced irregularity in the cycle and amount were categorized as peri-menopausal. Women who had no menstruation in the previous 12 months were categorized as post-menopausal.

Depressive symptoms were measured using the Center for Epidemiological Studies Depression Scale (CES-D), a self-reported depression scale for the general population (Radloff, 1977). The CES-D is composed of 20 items to measure the depressive symptoms over a 1-month period, and was scored using a four-point Likert-type scale ranging from 0 to 3, with higher scores indicating more depressive symptoms (Radloff, 1977). This study utilized a Korean version of the CES-D, which was translated and back-translated for use with Koreans. Reliability was estimated as Cronbach's α of .89 (Chon & Rhee, 1992; Shin, 2001). The Korean version showed good construct and concurrent validity compared to the diagnostic tests for clinical depression (Symptom Checklist-90-Revised; Chon & Rhee, 1992). The Cronbach's α in this study was .87.

Behavioral characteristics. Behavioral characteristics included the frequency of alcohol consumption, coffee intake, regular exercise, screen time, and late dinner consumption (after 8 pm). The influence of these lifestyle behaviors on sleep quality and sleep efficiency has been reported in former research (Madden et al., 2014; National Sleep Foundation, 2017). Questions were taken from the Korea National Nutrition and Health Survey Questionnaire (KNHANES, 2013). KNHANES is a nationwide cross-sectional survey conducted every year since 1998. Korea Centers for Disease Control and Prevention (KCDC) and related academic societies (e.g., Korean Academy of Family Medicine and Korean Society of Hypertension) have collaborated to manage the external and internal quality of the national survey, including improvement of survey instruments (KNHANES, 2016; Kweon et al., 2014).

The frequency, quantity, and age of initiating alcohol consumption were assessed. Participants were asked "how often do you drink alcohol?" and responded on an ordinal scale (*never*, *less than once a month*, *once a month*, *2–4 times*/*month*, *2–3 times*/*week*, or *at least 4 times*/*week*). The quantity of alcohol consumption in one occasion was measured with an ordinal scale (*never*, *1–2*, *3–4*, *5–6*, *7–9*, or *≥10 glasses*). Initiation age of alcohol consumption was measured by asking the women to provide the age when they first started drinking alcoholic beverages. Frequency of coffee consumption was measured using an ordinal scale (*never*, *less than once*/*day*, *twice*/*day*, or *at least 3 times*/day).

Six questions were used to measure exercise frequency. In three questions, participants provided the number of days they executed vigorous, moderate, and walking exercises at least 10 minutes/day during the past week. In another three questions, they were asked to provide the average minutes of executing vigorous, moderate and walking exercises per day during the same period. Those who performed vigorous exercise at least 20 minutes/day and 3 days/week, and/or those who performed moderate and/or walking exercises at least 30 minutes/day and 5 days/week were defined as regular exercisers (KNHANES, 2013). Vigorous exercise included jogging, climbing, bicycling, fast swimming, tennis, and carrying heavy loads, while moderate exercise included slow swimming, badminton, table tennis, tennis doubles, and carrying light loads.

A single question was used to determine screen time, "How many hours per day did you spend sitting while watching TV/video, using computers, and playing Internet games during last week?" and was scored on an ordinal scale (*<1 hour*, *1–2 hours*, *2–3 hours*, *3–4 hours*, or *≥4 hours*). Late dinner consumption was measured using a question, "How often did you eat a late dinner after 8 p.m. during the past week?" and scored on an ordinal scale from zero to everyday. The question of late dinner consumption was adopted from an earlier study (Ham, Sung, & Kim, 2013).

Socio-environmental characteristics. The level of stress was measured using the question, "How much stress do you feel in your normal life?" The question was scored on a four-point Likert-type scale from 1 (*very severe*) to 4 (*hardly any*). The stress question was obtained from the Korea National Nutrition and Health Survey Questionnaire (KNHANES, 2013).

Social support was measured with an instrument developed for use with Korean women by Park (1985) and modified by Kim (1994). It is composed of 17 items on perceived social support in four areas, including emotional, instrumental, informational, and appraisal support. Each item is scored on a five-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Park (1985) verified the construct validity of the instrument through factor analysis and multitrait-multimethod approach. In an earlier study, the Cronbach's α reliability was .98 (Kim, 1994), and it was .96 in the present study.

Sleep characteristics. The degree of insomnia was measured with the Insomnia Severity Index (ISI) developed by Bastien, Vallières, and Morin (2001). The ISI is composed of seven items including the severity of problems with sleep onset, sleep maintenance, and early morning awakening; satisfaction with current sleep pattern; interference with daily functioning; noticeability of impairment attributed to sleep problems; and level of distress caused by sleep problems during the last 2 weeks. These items were scored using a five-point Likert scale (0 = *not at all*, 4 = *extremely*). The total scores range from 0 to 28, and an earlier study suggested a score of 10 to be most useful as a cut-off for population screening for insomnia (Cuadros et al., 2012). The reliability of the instrument was verified in the original study with a Cronbach's α of .90 (Bastien et al., 2001). It was .92 in the present study. This study used the Korean version of the ISI, translated by the Korean Sleep Research Society (2002). The Korean version of the ISI demonstrated good convergent/discriminant validity in relation to other instruments measuring the sleep quality and sleepiness (Cho, Song & Morin, 2014).

Sleep quality over a 1-month period was assessed with the Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The PSQI contains 19 self-rated questions in seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Each question was scored from 0 to 3, and the global score of seven components ranged from 0 to 21. Scores >5 indicated poor sleep quality (Sohn, Kim, Lee, & Cho, 2012). The PSQI was translated and back-translated by Korean researchers for use with Koreans (Sohn et al., 2012), and we used the Korean version of the PSQI. The Korean version demonstrated good predictive and convergent validity in relation to sleep efficiency and sleep latency measures obtained by polysomnography (PSG; Sohn et al., 2012). The Cronbach's α was .84 in the original study (Sohn et al., 2012) and .81 in the present study.

The content validity of all psychometric study instruments, including personal, behavioral, socio-environmental, and sleep characteristics, was verified by three experts in the field of nursing and behavioral research. They also examined the readability, comprehensibility, and cultural appropriateness of the study instruments. The three experts were nursing professors with PhDs. Two professors were faculty in the department of behavioral health sciences and the department of family and community health within the college of nursing, respectively; the other professor was faculty in the division of women's health within the department of nursing.

CVD risk factors. BMI (kg/m^2) was calculated from the height (m) and weight (kg) measured using electronic scales (G-TECH [GL-150], 2006; Uijongbu, Kyunggi-do, Korea), while wearing light clothes and shoes off. The waist circumference (WC) was measured using a tape ruler to the nearest 0.1 cm at the high point of the iliac crest in a standing position. The blood pressure was measured twice at 30-second intervals on the right arm using an electronic sphygmomanometer after the subject had rested in the seated position, and the mean blood pressure was used in the analysis (Korea National Health & Nutrition Survey [KNHANES], 2014). Serum analyses included\fasting blood sugar (FBS), total cholesterol, triglyceride, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein (LDL) cholesterol. The FBS, total cholesterol, triglyceride, and HDL and LDL cholesterol levels were analyzed using enzymatic methods by the Planned Population Federation of Korea (PPFK). All biological samples were processed at the same laboratory within the PPFK branch office located in one city.

Procedures

The research team members met with the head of a branch office of the PPFK located in one metropolitan city area and requested their assistance in recruiting the study participants and data collection. PPFK is a nonprofit organization providing services for the health of families, youth, and elders. The staff members of the PPFK helped distribute fliers, posted banners, and provided a place for data collection within the PPFK. Potential participants voluntarily presented at the PPFK branch office to enroll in the study after initial telephone screening. The study purpose and methods were explained to the potential subjects before enrollment, and written informed consent was obtained. Those who agreed to enroll were given the survey questionnaires.

After completion of the survey, anthropometric and blood pressure measurements were taken by trained nurses. Blood samples were drawn by medical technicians in the clinical laboratory within the PPFK and sent for testing. Research assistants made phone calls to the participating women prior to the blood tests and instructed them to skip breakfast for blood testing on the day of data collection and not eat anything after 9 o'clock on the day before undergoing blood tests. After the blood samples were drawn, each participant received a $20.00 gift card. Data collection was conducted between June and August, 2015.

Data Analysis

The Statistical Package for the Social Sciences 21.0 for Windows was used for data analysis (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). Data were screened for data-entry accuracy and to ensure that the assumptions of the statistical tests were met. Descriptive statistics, such as frequencies, percentages, means, and standard deviations, were used to describe the personal, behavioral, socio-environmental, and sleep characteristics of the participants.

Hierarchical multiple regression analyses were conducted to examine the factors associated with insomnia (ISI) and sleep quality (PSQI). Variables were entered in three blocks. First, in Model 1, personal factors (demographic characteristics, menopausal status, BMI, and depressive symptoms) were entered as a block to examine whether these variables explained some of the variance in insomnia and sleep quality. In Model 2, behavioral factors (alcohol frequency, coffee intake, regular exercise, screen time, and eating behavior) were entered as the second block. In Model 3, socio-environmental factors (stress and social support) were entered as the third block. Last, analyses of covariance (ANCOVA) were conducted to examine differences in CVD risk factors in those with and without poor sleep characteristics (insomnia and sleep quality), with age and BMI entered as covariates. Two-tailed null hypotheses of no difference were rejected if the *p*-values were $<.05$.

Results

Personal Characteristics of the Participants

The mean age was 55.0 years (SD = 6.01, range 40–65). Two-thirds (67.6%) had completed education at the high school level or above, most were married or cohabited with a partner, fewer than half were employed, and most were post-menopausal. Forty-eight percent of the participants had a monthly family income equal to or less than 2.4 million won (national average household income in 2015, equals $2,400 US dollars). Based on the CES-D ($\geq$16), about one-third had depressive symptoms (Table 1).

Behavioral, Socio-Environmental, and Sleep Characteristics

Fifty-five percent consumed alcohol less than once/month, and the average age of initiating alcohol consumption was 27.2 years (SD = 9.87, range 12–60). While 68% exercised regularly (vigorous exercise at least 20 minutes/day and 3

Table 1. Personal Characteristics of Sample of Middle-Aged Korean Women (*N* = 423)

Variable	Categories	*n*	%
Age	≤49	69	16.3
	50–59	242	57.2
	60–65	112	26.5
Education	≤Elementary	32	7.6
	Middle school	105	24.8
	High school	215	50.8
	≥College	71	16.8
Income	≤2.4 million won[a]	198	48.3
	>2.4 million won	212	51.7
Marital status	Married/cohabiting	341	81.0
	Single/divorced/widowed	80	19.0
Employment	Yes	199	47.0
	No	224	53.0
Menopausal status	Pre-menopause	81	19.1
	Peri-menopause	33	7.8
	Post-menopause	309	73.0
CES-D	Low depressive symptoms (<16)	263	62.8
	Depressive symptoms (≥16)	156	37.2

Note: CES-D = Center for Epidemiologic Studies Depression Scale.
[a]2.4 million won (₩) is the national average household income in 2015 and equates to $2,400 US.

days/week, and/or moderate and/or walking exercises at least 30 minutes/day and 5 days/week), 23.9% spent screen time at least 3 hours/day, 75.4% ate late dinner (after 8 pm) at least once a week, and 16.7% perceived severe or very severe stress. Twenty-five percent reported insomnia (ISI $\geq$ 10), and 41.3% had poor sleep quality (PSQI > 5; Table 2). The mean PSQI score was 5.46 (SD = 3.21, range 0–17). The mean social support score was 60.32 (SD = 13.49, range 0–85).

CVD Risk Factors

The women's mean BMI was 24.03 kg/m^2 (SD = 2.91, range 17.6–35.1) and the mean WC was 77.82 cm (SD = 8.61, range 57.2–103.6). Thirty percent had FBS levels greater than or equal to 100 mg/dl, 52.2% had total cholesterol levels at least 200 mg/dl, 27.9% had triglyceride levels at least 150 mg/dl, 15.8% had LDL cholesterol levels at least 160 mg/dl, and 15.4% had HDL cholesterol levels lower than 50 mg/dl. The mean SBP was 121.71 (SD = 15.58, range 62.5–191.5), and mean DBP was 72.37 (SD = 9.66, range 50.0–107.5) (Table 3).

Social Cognitive Factors Associated With Insomnia and Sleep Quality

In hierarchical multiple regression to determine predictors of insomnia, in Model 1 (first block entered), personal factors accounted for 26.4% of the variability in the ISI (F = 15.52, $p < .001$), and more depressive symptoms were associated with higher ISI score ($p < .001$). In Model 2 (2 blocks entered), with behavioral factors in the model, explained variance increased by 1.7% (F = 10.76, $p < .001$). Screen time ($\geq$3 hours/day) and a lower education level ($\leq$middle school) were positively associated with the ISI score ($p < .05$). In Model 3, the addition of socio-environmental factors increased the explained variance by 1.7%, and the perception of severe stress was associated with higher ISI score ($p < .01$). Variables in the final model accounted for 29.9% of the variance in the level of insomnia (F = 10.18, $p < .001$).

In predictors of sleep quality, among personal factors, more depressive symptoms were positively associated with the PSQI in Model 1 (R^2 = .220, F = 12.01, $p < .001$). In Model 2, the addition of behavioral factors increased the explained variance by 1.5% (F = 8.31, $p < .001$), but none of the behavioral factors were significantly associated with the PSQI ($p > .05$). In Model 3, the addition of socio-environmental factors increased the explained variance by 2.3%, and perception of severe stress was positively associated with the PSQI ($p < .001$). Variables in the model accounted for 25.9% of variance in sleep quality (F = 8.20, $p < .001$; Table 4).

Relationship of CVD Risk Factors to Sleep Characteristics

Total cholesterol and LDL cholesterol levels were significantly higher in individuals with insomnia, after controlling

Table 2. Behavioral, Socio-Environmental, and Sleep Characteristics (*N* = 423)

Variable	Category	*n*	%
Alcohol consumption frequency	<1/month	231	54.6
	1–4 times/month	151	35.7
	>Once/week	41	9.7
Quantity of alcohol consumption	None	77	18.2
	1–2 glasses	154	36.4
	3–4 glasses	90	21.3
	5–6 glasses	22	5.2
	7–9 glasses	11	2.6
	≥10 glasses	2	0.5
	Missing	67	15.8
Coffee consumption	≤1 cup/day	227	53.8
	≥2 cups/day	195	46.2
Regular exercise[a]	Yes	287	67.9
	No	136	32.1
Screen time	<3 hours/day	321	76.1
	≥3 hours/day	101	23.9
Frequency of late dinner (after 8 pm)	None	104	24.6
	≥1 day/week	319	75.4
Stress	Very severe	7	1.7
	Severe	63	15.0
	Moderate/mild	271	64.5
	Hardly ever	79	18.8
ISI	Absence (0–9.9)	317	74.9
	Insomniac (≥10)	106	25.1
PSQI	Good quality (0–5)	244	58.7
	Poor quality (>5)	172	41.3

Notes: ISI = Insomnia Severity Index, PSQI = Pittsburgh Sleep Quality Index. Missing data were excluded from analysis.
[a]Vigorous exercise at least 20 minutes/day and 3 days/week, and/or moderate exercise or walking at least 30 minutes/day and 5 days/week.

Table 3. Distribution of Cardiovascular Disease Risk Factors (*N* = 423)

Variable	Categories	*n*	%
BMI (kg/m^2)	Normal weight or below (<25)	285	67.4
	Overweight (25–29.9)	124	29.3
	Obese (≥30)	14	3.3
WC (cm)	<85	330	78.0
	≥85	93	22.0
FBS (mg/dl)	<100	297	70.2
	≥100	126	29.8
Total cholesterol (mg/dl)	<200	202	47.8
	≥200	221	52.2
Triglyceride (mg/dl)	<150	305	72.1
	≥150	118	27.9
HDL cholesterol (mg/dl)	<50	65	15.4
	≥50	358	84.6
LDL cholesterol (mg/dl)	<160	356	84.2
	≥160	67	15.8
SBP (mmHg)	<120	186	44.0
	120–139	192	45.4
	≥140	45	10.6
DBP (mmHg)	<80	339	80.1
	80–89	67	15.8
	≥90	17	4.0

Notes: BMI = body mass index, WC = waist circumference, FBS = fasting blood sugar, HDL cholesterol = high density lipoprotein cholesterol, LDL cholesterol = low-density cholesterol, SBP = systolic blood pressure, DBP = diastolic blood pressure.

Table 4. Factors Associated With Insomnia (ISI) and Sleep Quality (PSQI) in Hierarchical Multiple Regression (*N* = 423)

	ISI			PSQI		
	Model 1 ß	Model 2 ß	Model 3 ß	Model 1 ß	Model 2 ß	Model 3 ß
Age	−.017	−.013	.015	−.059	−.051	−.020
Education	−.089	−.105*	−.107*	−.033	−.054	−.058
Income	.090	.092	.088	.022	.026	.033
Occupation	.019	.005	.016	−.045	−.040	−.027
Marital status	−.029	−.042	−.033	.025	.011	.024
Menopause (post-menopause)						
Pre-menopause	−.028	−.012	−.005	−.021	−.005	.005
Peri-menopause	.049	.052	.066	.016	.014	.036
BMI	.046	.038	.046	.082	.070	.079
Depressive symptoms	.494***	.480***	.434***	.458***	.448***	.374***
Alcohol frequency		−.024	−.016		−.077	−.070
Coffee intake		−.053	−.057		−.039	−.048
Regular exercise		−.042	−.042		−.039	−.035
Screen time		.105*	.091*		.042	.022
Late dinner after 8 pm		.027	.023		.083	.074
Stress			−.138**			−.179***
Social support			.082			.037

Notes: Standardized regression coefficients. Education: 1 = middle school or less, 2 = high school or above; income: 1 = equal to or less than 2.4 million won, 2 = over 2.4 million won; occupation: 1 = yes, 2 = no; marital status: 1 = married/cohabiting, 2 = single/separated/widowed/divorced; regular exercise: 1 = yes (vigorous exercise at least 20 minutes/day and 3 days/week, and/or moderate exercise or walking at least 30 minutes/day and 5 days/week), 0 = no; screen time: 1 = less than 3 hours/day, 2 = at least 3 hours/day; alcohol frequency: 1 = less than once/month, 2 = at least once/month; coffee intake: 1 = equal to or less than 1 cup/day, 2 = at least 2 cups/day; late dinner after 8 pm: 1 = no, 2 = at least once/week; ISI = Insomnia Severity Index, PSQI = Pittsburgh Sleep Quality Index, BMI = body mass index.

**$p < .05$

**$p < .01$

***$p < .001$

for age and BMI ($p < .05$). The BMI was higher in the poor sleep quality group ($p < .05$) than in the normal sleep group ($p < .05$; Table 5).

Discussion

In the present study, we found that personal (education and depressive symptoms), behavioral (screen time), and socio-environmental factors (stress) were associated with insomnia and/or poor sleep quality. Among CVD risk factors, the total cholesterol and LDL cholesterol levels were significantly related to insomnia, while the BMI was associated with poor sleep quality. This study is unique in that we explored multi-dimensional factors associated with insomnia and sleep quality based on Social Cognitive Theory, and examined the resulting cardiovascular health status of women with insomnia and poor sleep quality.

Prevalence of Insomnia and Sleep Quality in Middle-Aged Women

In our study, 25.1% of middle-aged women had experienced insomnia (ISI $\geq$ 10). This is a lower prevalence of insomnia compared to earlier studies, in which 36.6% (Cuadros et al., 2012) and 42% of the women (Cho, 2002) exhibited insomnia symptoms. This may be due to differences in the definitions of insomnia and the age range of the participants across the studies. Using the PSQI, 41.3% were identified as having poor sleep quality, and the mean score was 5.46 ± 3.21, which is similar to middle-aged women in the United States (5.1 ± 2.8; Knutson, Rathouz, Yan, Liu, & Lauderdale, 2006), but lower than that reported in China among female adults (7.03 ± 3.06; Hung et al., 2013). Despite the lower mean PSQI score, the prevalence of poor sleep quality in the present study may indicate a need for interventions to alleviate sleep problems.

Factors Associated With Insomnia and Sleep Quality

Lower education level ($\leq$middle school), more depressive symptoms, high screen time ($\geq$3 hours/day), and perception of severe stress were associated with the presence of insomnia symptoms, while more depressive symptoms and severe stress were associated with poor sleep quality. Insomnia and depression may simply co-occur, or other precipitating or maintaining mechanisms, such as stress or illness, may explain the relationship between insomnia and depression (Jansson-Fröjmark & Lindblom, 2008). A hypothesis is that insomnia and depression are reciprocal, in that depression is reported as a common antecedent of chronic insomnia, and insomnia is strongly associated with the risk of developing depression. About 90% of patients with depression will report sleep problems, while insomnia increases the odds of depression fourfold over a 3-year period (Franzen & Buysse, 2008). Other teams also reported a bidirectional association between poor sleep quality and depression (Kang, Lee, Jang, Kim & Sunwoo, 2013; Pensuksan et al., 2016).

Hormonal alterations also may explain the association between insomnia and depression. Indeed, both insomnia and depression have similar hormonal or neurotransmitter alterations including hypercortisolemia, reduced serotonin (a

Table 5. CVD Risk Factors Associated With Insomnia (ISI) and Sleep Quality (PSQI) in ANCOVA (*N* = 423)

	ISI						PSQI					
	No Insomnia		Insomnia				Good Sleep Quality		Poor Sleep Quality			
	M	*SD*	*M*	*SD*	*F*	*p*	*M*	*SD*	*M*	*SD*	*F*	*p*
BMI	23.90	2.83	24.41	3.12	1.83	.176	23.76	2.73	24.37	3.03	4.52	.034*
WC	77.44	8.24	78.93	9.58	1.67	.197	77.10	7.78	78.73	9.52	3.51	.062
FBS	98.28	18.66	97.07	12.17	1.23	.268	97.53	16.61	98.55	18.27	.09	.766
Total cholesterol	199.10	34.40	209.99	35.13	7.14	.008**	200.14	33.52	204.40	36.32	1.30	.256
Triglyceride	123.10	71.77	126.99	75.59	.00	.993	123.90	71.72	124.34	71.14	.12	.727
HDL cholesterol	63.60	25.62	64.41	12.33	.40	.526	62.70	12.88	65.38	32.56	2.30	.130
LDL cholesterol	123.41	33.45	132.82	33.19	5.41	.021*	124.43	34.10	127.77	32.93	.72	.397
SBP	121.54	15.74	122.19	15.15	.04	.845	120.69	15.17	122.92	15.61	.87	.352
DBP	72.30	9.76	72.57	9.38	.02	.901	71.94	9.32	72.92	9.99	.32	.573

Note: Age and BMI were covariates. For BMI and WC, only age was inserted as a covariate. ISI = Insomnia Severity Index, PSQI = Pittsburgh Sleep Quality Index, BMI = body mass index, WC = waist circumference, FBS = fasting blood sugar, HDL cholesterol = high-density lipoprotein cholesterol, LDL cholesterol = low-density lipoprotein cholesterol, SBP = systolic blood pressure, DBP = diastolic blood pressure.

*$p < .05$

**$p < .001$

monoamine neurotransmitter involved in the regulation of sleep), and decreased norepinephrine metabolism and dopamine neurotransmission (González et al., 2012; Hasler, 2010). Norepinephrine receptors form heteromers through an interaction with other dopamine receptors. Heteromerization is defined as the interaction between two different receptors, resulting in the formation of component unit, which has different functional properties from the original ones (Albizu, Moreno, González-Maeso, & Sealfon, 2010). Through receptor heteromers, dopamine inhibits the effects of norepinephrine, which is associated with the synthesis and secretion of melatonin (González et al., 2012; Hasler, 2010). Therefore, those hormonal or neurotransmitter alterations may induce insomnia, depression, or both, due to increased cortisol and reduced serotonin and melatonin.

As in this study, higher educational attainment was associated with less insomnia in adults who participated in the National Health Interview Survey (Cunningham et al., 2015). Others also found that education and income were associated with sleep complaints among adults, and the association between education and sleep problems was stronger in women than in men. As in our study, the risk of sleep problems associated with low income was greatly attenuated in an adjusted model, while the effects of education on sleep were relatively robust (Grandner et al., 2010). These results may indicate that educational attainment is a significant predictor in determining sleep problems. However, the mechanism of how the level of education influences sleep problems is unclear.

Among behavioral factors, screen time was positively associated with insomnia in our study, which is consistent with an earlier study (Madden et al., 2014) in which sedentary behavior was negatively associated with sleep efficiency. Authors contended that physical activity was beneficial for obstructive sleep apnea, depressive symptoms, and restless leg syndrome, all of which affect insomnia and sleep quality. Melatonin levels decreased with increased time in sedentary behaviors among nurses, which is a potential mechanism of association between sedentary behavior and sleep problems (McPherson et al., 2011).

Stress is regarded as the primary cause of insomnia, and stress and sleep quality among women are negatively associated (Åkerstedt et al., 2012; Cuadros et al., 2012). We also found that stress was associated with insomnia and poor sleep quality. The hypothalamic-pituitary-adrenal (HPA) axis stimulates release of corticotrophin-releasing hormone (CRH) and cortisol under stress, causing arousal and sleeplessness (Basta, Chrousos, Vela-Bueno, & Vgontzas, 2007). Generally, cortisol has a diurnal variation in that it is highest in the early morning, drops during the day, and is lowest around midnight (Cohen et al., 2006). However, among insomniacs, hypercortisolemia occurs during nighttime (Hasler, 2010), and significantly higher cortisol levels were observed in evening and during the night compared to good sleepers (Basta et al., 2007). Therefore, stress causes hyperarousal, making it difficult to fall asleep, stay asleep, and affecting sleep quality (Kavey, 2016).

Association Between Sleep Problems and the CVD Risk Profile

In this study, insomnia was significantly associated with increased total cholesterol and LDL cholesterol levels, while poor sleep quality was associated with increased BMI. Other teams also have reported associations between sleep disturbance and CVD risks (Nagai et al., 2010; Quan, 2009; Taylor et al., 2014). Dyslipidemia was associated with diminished sleep and disturbed sleep (Kong et al., 2011; Mahmood et al., 2013; Toyama et al., 2013). Sleep disturbances are associated with multiple hormonal changes (elevated cortisol and ghrelin levels and lower leptin levels), reduced insulin sensitivity, and increased sympathetic nervous system activation (Kong et al., 2011; Mahmood et al., 2013). These changes would be associated with the development of dyslipidemia, a major risk factor for CVD (Kong et al., 2011; Toyama et al., 2013).

Similar to our study, earlier investigators observed that sleep disturbance was associated with obesity (Gangwisch, Malaspina, Boden-Albala, & Heymsfield, 2005; Gupta, Mueller, Chan, & Meininger, 2002). Chronic sleep loss and sleep disorders are associated with harmful health outcomes including hypertension, diabetes, and obesity (Institute of Medicine, 2006). The association between sleep disturbance and obesity could be also explained by hormonal mechanisms. Short sleep could result in decreased leptin levels (satiety hormone) and increased ghrelin levels (hunger hormone), thus markedly elevating hunger and appetite, which in turn can lead to overweight/obesity (Gupta et al., 2002). Although this cross-sectional design could not ascertain the temporal relationships between these variables, high BMI was included as a factor that contributes to the development of sleep disorders and their health consequences.

Limitations

The study limitations include the cross-sectional study design, restricting interpretation of the results to associations. Causal conclusions cannot be drawn. The convenience sampling method limits the generalizability of the study results. This study excluded women who were using sleeping pills, thus the prevalence and severity of insomnia and sleep quality may have been underestimated. In measuring stress, we employed a subjective indirect measure of stress using a single-item scale, instead of a validated instrument, such as Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983) or physiological stress measures (i.e., cortisol). Nevertheless, an earlier study verified the validity of a single-item measure of stress recorded on a 5-point Likert scale (Elo, Leppänen, & Jahkola, 2003). Another limitation was the self-report data collection method, in which respondents may give what they believe to be more favorable responses, which may produce social acceptance bias. In addition, with a large sample size, statistically significant results may occur even with small clinically insignificant differences (Hochster, 2008). Finally, 25.1% of subjects reported experiencing insomnia, but 41.3% indicated that they suffered from poor sleep quality. This suggests that there may exist other reasons for poor sleep beyond insomnia that were not explored in this study (i.e., obstructive sleep apnea syndrome, pain, and insufficient sleep) and may have increased the risk of CVD in these women.

Implications for Clinical Practice

Because personal, behavioral, and socio-environmental factors were associated with sleep problems, the relationships of these variables should be considered in developing interventions to mitigate sleep problems. The relationship between education and insomnia may indicate that efforts to alleviate socioeconomic disparities in health, including sleep problems, are needed. Socioeconomic status is a complex mixture of income, occupation, and education. The latter is regarded as a knowledge-based capital, and is strongly associated with income and occupation. Thus, education may have direct and/or indirect effects on health through multiple pathways (Howe et al., 2012). Therefore, strengthening of knowledge-based capital through health education and health promotion programs can help bridge the gap between socioeconomic groups.

Middle-aged women are exposed to multiple stressors, and report more stress in their lives than men (Cuadros et al., 2012; Ham, 2011). Because stress causes hyperarousal and affects sleep quality through cortisol production (Basta et al., 2007), tailored approaches to alleviate stress should be incorporated based on an assessment of the sources of stress. Practitioners should be aware that stress, insomnia, and depression have similar hormonal and neurotransmitter alterations. The occurrence of one can accompany the others. Thus, when treating insomnia, an assessment of comorbid conditions should be included in the care plan and approaches to prevent or alleviate these comorbid conditions should be followed. Cognitive behavioral therapy (CBT) could be an initial nonpharmacological treatment to alleviate the symptoms of insomnia and poor sleep quality. The components of CBT may include stimulus control (limiting time in bed when unable to fall asleep), sleep hygiene education, and relaxation training (Perlis, Jungquist, Smith, & Posner, 2008). CBT has been found effective for insomnia in former studies (de Bruin, Oort, Bögels, & Meijer, 2014; Yamadera et al., 2013).

Implications for Future Research

Future studies should include a pathophysiological assessment of sleep problems and determine whether sleep interventions both alleviate insomnia and correct hormonal and neurotransmitter alterations. Similarly, whether sleep interventions can reduce CVD risks through a restoration of biochemical and/or hormonal alterations could be investigated in future research. Such alterations may include insulin sensitivity, sympathetic nervous system activation, and cortisol, ghrelin, and leptin hormones.

Future studies may include examining gender differences in frequency and severity of sleep problems and differentiating factors associated with men's and women's sleep problems to explore whether these differences are biological (e.g., hormonal and neurotransmitter) and/or psychological or socio-environmental. The results will help develop sleep interventions tailored for each gender.

Conclusion

Using predictors based on Social Cognitive Theory, we examined the personal, behavioral, and socio-environmental factors associated with insomnia and sleep quality, and investigated associated health status (CVD risk profile) in 423 middle-aged women recruited in a community setting. Education, depressive symptoms (personal), screen time (behavioral), and stress (socio-environmental factors) were associated with insomnia (ISI) and/or poor sleep quality (PSQI), while BMI, total cholesterol, and LDL cholesterol levels differed significantly according to the sleep characteristics. One-quarter reported insomnia and more than one-third were identified as having poor sleep quality. Approaches to deal with the multiple predictors of poor sleep and their health consequences should be incorporated in sleep interventions.

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Conflict of interest

The authors declare no conflicts of interest.

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