JOMH
Journal of Men's Health

J. Mens. Health **2022**; 18(6): 126
https://doi.org/10.31083/j.jomh1806126

Original Research

Effects of body size phenotype on sleep quality in middle-aged Korean men

Ji Young Kim[1], Youngran Yang[2,*,†], Sung-Heui Bae[3,†]

[1]Department of Nursing, Wonkwang Health Science University, 54538 Iksan, Republic of Korea
[2]College of Nursing, Research Institute of Nursing Science, Jeonbuk National University, 54896 Jeonju, Republic of Korea
[3]College of Nursing, Graduate Program in System Health Science and Engineering, Ewha Womans University, 03760 Seoul, Republic of Korea
*Correspondence: youngran13@jbnu.ac.kr (Youngran Yang)
[†]These authors contributed equally.
Submitted: 27 September 2021 Accepted: 26 November 2021 Published: 27 May 2022

Abstract

Background: Research on body size phenotype according to metabolic syndrome and obesity is being actively conducted. Quality of sleep can vary depending on the body size phenotype. This study aimed to investigate the effects of body size phenotype on sleep quality in middle-aged Korean men. **Methods**: This study used secondary data analysis from a community-based cohort of the Korean Genome and Epidemiology Study (KoGES). Using BMI and metabolic health status, among 3675 men aged between 40 and 65 years, body size phenotypes were classified as follows: metabolically healthy normal weight (MHNW) (50.8%), metabolically healthy obesity (MHO) (32.5%), metabolically abnormal obesity (MAO) (12.7%), and metabolically abnormal but normal weight (MANW) (4.0%). **Results**: MANW men had the most prolonged sleep duration (more than 7 hours), and MHO men had the shortest sleep duration. The degree of difficulty falling back to sleep after waking in MHO men was 0.76 times that of MHNW men ($p = 0.02$). **Conclusions**: Sleep duration and difficulties falling back to sleep were independently associated with body size phenotype in middle-aged men after adjusting for confounding factors. Health professionals and officials in labor departments may use the results of this study to improve the quality of sleep and ultimately help with productivity in the workplace.

Keywords: body size phenotype; Korea; men; metabolically healthy obesity; sleep quality

1. Introduction

Obesity is a significant public health concern and has become a global epidemic. Globally, more than 650 million people were obese in 2016, and this figure has nearly tripled since 1975 [1]. In South Korea, the prevalence of obesity in the Korean adult population in 2019 was 41.8% for men, 25% for women, 45% for men in their 40s, 43.4% for men in their 50s, 25.8% for women in their 40s, and 29.6% for women in their 50s, showing the highest prevalence among middle-aged men [2].

Recently, a growing body of evidence has emerged on health results by body size phenotype depending on the combination of obesity and the metabolic syndrome (2 × 2): (1) metabolically healthy normal weight (MHNW), (2) metabolically healthy obesity (MHO), (3) metabolically abnormal but normal weight (MANW), and (4) metabolically abnormal obesity (MAO). Of these phenotypes, MHO is characterized by a lack of metabolic abnormalities, such as dyslipidemia, insulin resistance, and high blood pressure [3], and researchers' interest in MHO is growing. Individuals with the MHO phenotype are reported to have a 24% higher risk of a high prevalence of and mortality due to cardiovascular disease, type 2 diabetes, and cancer than individuals with the MHNW phenotype [4,5]. The prevalence of MHO varies from 6% to 75%, depending on the definition, country, gender, age, and lifestyle [6]; 70.4% of middle-aged obese Korean men were classified as MHO using the definition of the National Cholesterol Education Program (NCEP) [7].

In considering the increasing research on the outcome of diabetes, hypertension, and mortality according to body size phenotypes, the lack of studies on the relationship between MHO and sleep disorders has been addressed [8]. Excessive decreases or increases in sleep duration, insomnia, and difficulty maintaining sleep increase the risk of cardiovascular disease and negatively affect quality of life [9]. Thus, to fill the study gap, this current study focused on the impact of body size phenotypes on sleep quality.

Previous studies demonstrated the impact of obesity and body size phenotype on sleep quality. For example, obesity is associated with short and long sleep duration and poor sleep quality [10,11]. In a study by Kanagasabai, Dhanoa, Kuk *et al*. [12], MHO individuals almost always had sleep disorders, woke up regularly during the night, and had daytime instability and excessive drowsiness [12]. A study of Americans reported higher sleep times in MHO than MAO for women, and the opposite is true for men [13]. These studies suggest that body phenotypes provide a new strategy to analyze the improvement of sleep quality and quality of life in obese patients by predicting sleep quality. Poor sleep quality worsens metabolic syndrome and insulin resistance components, leading to diabetes, hypertension,

hyperlipidemia, and heart disease in otherwise healthy individuals [14]. A prospective study of German adults with an average follow-up duration of 7.5 years revealed that those who had difficulty falling asleep had an increased risk of type 2 diabetes [15]. Thus, ensuring a good quality of sleep for individuals becomes more important in ensuring long-term health.

Middle-aged men who have many responsibilities and obligations in society and at home, including increased personal and family responsibilities, are exposed to substantial stress, affecting sleep quality [16]. Men have worse sleep quality (longer sleep onset latency and lower sleep efficiency) than women [17,18]. The mortality risk is four times higher in men who sleep fewer than 6 hours per day than men who sleep longer, but this difference has not been shown in women [9].

Middle-aged men who have poor sleep quality have been shown to have a high obesity rate, but research to build scientific evidence for effective interventions is lacking, which is a concern given that obesity is a major cause of metabolic disorders. Still, recent studies have increased the interest in the health outcomes of individuals with an MHO phenotype, simultaneously considering obesity and metabolic syndrome. However, studies on sleep and body size phenotypes, especially in middle-aged men with a high prevalence of obesity, are extremely lacking. This study aimed to investigate the difference in sleep quality according to the four body phenotypes in middle-aged Korean men to inform the evidence-based practice for sleep management services at the community level.

The hypotheses of this study are as follows: (1) sleep duration will vary according to body size phenotype. (2) The quality of sleep will depend on the body size phenotype.

2. Methods

2.1 Data and study population

This study used secondary data analysis with 2001–2002 baseline data from the community-based cohort of the Korean Genome and Epidemiology Study (KoGES) provided by the Korea Centers for Disease Control and Prevention (KCDC). KoGES has established a large-scale cohort for the prevention and management of cardiovascular disease for the general population aged between 40 and 69 years by the KCDC. A copy of the complete survey is available from the primary author.

Of 4165 men aged 40 to 65 years who completed the baseline survey, those meeting the following conditions that could affect sleep were excluded: BMI less than 18.5 kg/m^2, arteriosclerosis, myocardial infarction, cerebrovascular diseases (such as stroke, cerebral infarction, and cerebral hemorrhage), thyroid disease, kidney disease, various cancers (n = 416), and missing data (n = 74). A total of 3675 men were included in the final analysis.

2.2 Definitions of metabolic syndrome and obesity

Metabolic syndrome was defined by the NCEP Adult Treatment Panel III (NCEP-ATP) [19] as the presence of three or more of the following five risk factors: (1) elevated waist circumference ($\geq$90 cm), (2) elevated triglycerides ($\geq$150 mg/dL), or the use of medication for hyperlipidemia, (3) reduced high-density lipoprotein cholesterol (HDL-C) ($<$40 mg/dL), (4) elevated blood pressure (systolic blood pressure $\geq$130 mm Hg or diastolic blood pressure $\geq$85 mm Hg), or the use of antihypertensive medication, and (5) elevated fasting glucose ($\geq$100 mg/dL), or the use of antihyperglycemic medication. Obesity was defined using the Asian standard for BMI, 25 kg/m^2 or more [20]. As a result, we created four different body size phenotypes based on metabolic syndrome and obesity.

2.3 Quality of sleep

Sleep quality was assessed using one question about sleep duration and two questions about sleep difficulties. Sleep duration was divided into three groups using the responses to the item "How many hours do you usually sleep?". 6 hours or fewer, 7 to 8 hours, or 9 hours or more. Two questions asked about sleep difficulties were: (1) "Have you had difficulty falling asleep in the last month?" (Difficulty falling asleep, yes/no) and (2) "Have you had trouble falling back to sleep after waking in the past month?" (Difficulty falling back to sleep, yes/no).

2.4 General information

Participants provided demographic information on age, marital status, education level, monthly income, and occupational status. Age was categorized into 40–49, 50–59, and 60–64 years old based on the time of the base survey. Marital status was categorized into "having a spouse", "yes" or "no". Education level was classified into "high school graduates or below" and "college graduates or above". Monthly income level was classified into three groups: monthly wage of $<$200, 200 to $<$400, and $\geq$400 $\times$ 10^4 won. Occupational status was divided into two categories, "employed" or "unemployed".

Health-related information (subjective health status, fatigue, and insomnia) and health behavior (drinking status, smoking status, and physical activity) were also examined. Subjective health status was categorized into "healthy" ("healthy", "very healthy"), "average", and "unhealthy" ("poor", "very unhealthy") as answers to the question, "How would you rate your overall health?". Fatigue was divided into "yes" or "no" according to the question "Lately, have you been feeling tired often?". Insomnia was divided into "yes" or "no" according to the question "Do you have insomnia?". Drinking status was divided into "yes" or "no" according to the question "Do you abstain from drinking alcohol (for religious or other reasons)?". Smoking status was divided into "yes" or "no" according to the question "To date, have you smoked more than 20 packs

Table 1. Sleep duration according to participants' characteristics (n = 3675).

Characteristics	Categories	n (%)	Sleep duration (per night)			χ^2 or F	*p*
			≤6 h	7~8 h	≥9 h		
			n (%) or M ± SD	n (%) or M ± SD	n (%) or M ± SD		
Total	Sleep duration		1551 (42.2)	1842 (50.1)	282 (7.7)		
Age (yr)	40–49	2057 (56.0)	865 (42.1)	1030 (50.1)	162 (7.9)	2.86	0.58
	50–59	1093 (29.7)	477 (43.6)	540 (49.4)	76 (7.0)		
	60–64	525 (14.3)	209 (39.8)	272 (51.8)	44 (8.4)		
Spouse	Yes	3548 (97.0)	1511 (42.6)	1772 (49.9)	265 (7.5)	5.20	0.07
	No	109 (3.0)	39 (35.8)	56 (51.4)	14 (12.8)		
Education	≤High school	3173 (86.8)	1302 (41.0)	1603 (50.5)	268 (8.4)	27.96	<0.001
	≥College	483 (13.2)	241 (49.9)	230 (47.6)	12 (2.5)		
Monthly income (10,000 won)	<200	2336 (64.5)	922 (39.5)	1198 (51.3)	216 (9.2)	38.80	<0.001
	200–<400	1003 (27.8)	477 (47.6)	477 (47.6)	49 (4.9)		
	≥400	280 (7.7)	136 (48.6)	133 (47.5)	11 (3.9)		
Occupation	Employed	2616 (71.4)	1064 (40.7)	1344 (51.4)	208 (8.0)	8.38	0.02
	Unemployed	1047 (28.6)	480 (45.8)	495 (47.3)	72 (6.9)		
BMI (kg/m^2)			24.85 ± 3.00	24.72 ± 3.05	24.49 ± 3.05	1.93	0.15
Self-reported health status	Healthy	1180 (32.2)	508 (43.1)	587 (49.7)	85 (7.2)	5.88	0.21
	Average	1330 (36.3)	549 (41.3)	689 (51.8)	92 (6.9)		
	Unhealthy	1153 (31.5)	489 (42.4)	560 (48.6)	104 (9.0)		
Fatigue	Yes	2110 (58.0)	928 (44.0)	1027 (48.7)	155 (7.3)	5.71	0.06
	No	1527 (42.0)	611 (40.0)	796 (52.1)	120 (7.9)		
Insomnia	Yes	583 (16.0)	310 (53.2)	229 (39.3)	44 (7.5)	36.47	<0.001
	No	3070 (84.0)	1230 (40.1)	1605 (52.3)	235 (7.7)		
Alcohol	Yes	1763 (48.2)	733 (41.6)	897 (50.9)	133 (7.5)	0.84	0.66
	No	1894 (51.8)	812 (42.9)	935 (49.4)	147 (7.8)		
Smoking	Yes	916 (25.2)	344 (37.6)	499 (54.5)	73 (8.0)	11.30	0.004
	No	2724 (74.8)	1194 (43.8)	1323 (48.6)	207 (7.6)		
Physical activity	Yes	1482 (41.1)	536 (36.2)	807 (54.5)	139 (9.4)	40.48	<0.001
	No	2128 (58.9)	987 (46.4)	1003 (47.1)	138 (6.5)		

BMI, body mass index; WC, waist circumference; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; HDL-C; high density lipoprotein cholesterol.

of cigarettes (400 cigarettes)?". According to whether or not they engaged in physical activity (intense activity) during the day, participants selected "yes" or "no".

2.5 Data analysis

The differences in body size phenotype, sleep duration, and difficulties according to the characteristics of the participants were determined using the χ^2-test and one-way ANOVA. The mean sleep duration according to body size phenotype was analyzed by ANCOVA with the Tukey post hoc test, and the difference in sleep difficulties according to the body size phenotype was determined by a binary logistics analysis to calculate an odds ratio (OR) and 95% confidence interval (95% CI). ANCOVA and logistic analyses were performed with Model 1 (no control variable), Model 2 (variables significant in the univariate analysis), and Model 3 (Model 2 + insomnia). The significance level of all analyses was set at $p < 0.05$. The data analysis was conducted in SPSS version 24.0 (IBM Corp., Armonk, NY, USA) for Windows.

3. Results

3.1 Differences in sleep duration and difficulties according to participant characteristics

Among 3675 men, the prevalence of each phenotype was about half for MHNW, about 33% for MHO, about 13% for MAO, and 4% for MANW. Of all participants, about 42% slept fewer than 6 hours, and about 8% slept more than 9 hours. Men who had an education level higher than college, were unemployed, had insomnia, did not smoke, and who practiced physical activity during the day slept fewer than 6 hours more frequently (Table 1).

Of all participants, about 13% had difficulty falling asleep, and 13% had difficulty falling back to sleep after waking. Men who had an education level lower than high school, had a monthly income less than 2 million won, were

Table 2. Sleep disorder according to participants' characteristics (n = 3675).

Characteristics	Categories	n (%)	Difficulty in falling asleep		χ^2 or F	p	Difficulty in falling asleep again		χ^2 or F	p
			Yes	No			Yes	No		
			n (%) or M ± SD	n (%) or M ± SD			n (%) or M ± SD	n (%) or M ± SD		
			475 (12.9)	3200 (87.1)			479 (13.0)	3196 (87.0)		
Age (yr)	40–49	2057 (56.0)	288 (14.0)	1769 (86.0)	4.82	0.09	279 (13.6)	1778 (86.4)	1.19	0.55
	50–59	1093 (29.7)	127 (11.6)	966 (88.4)			134 (12.3)	959 (87.7)		
	60–64	525 (14.3)	60 (11.4)	465 (88.6)			66 (12.6)	459 (87.4)		
Spouse	Yes	3548 (97.0)	454 (12.8)	3094 (87.2)	0.74	0.39	457 (12.9)	3091 (87.1)	1.24	0.27
	No	109 (3.0)	17 (15.6)	92 (84.4)			18 (16.5)	91 (83.5)		
Education	≤High school	3173 (86.8)	445 (14.0)	2728 (86.0)	27.89	<0.001	445 (14.0)	2728 (86.0)	22.64	<0.001
	≥College	483 (13.2)	26 (5.4)	457 (94.6)			30 (6.2)	453 (93.8)		
Monthly income (10,000 won)	<200	2336 (64.5)	344 (14.7)	1992 (85.3)	21.71	<0.001	349 (14.9)	1987 (85.1)	24.26	<0.001
	200–<400	1003 (27.8)	91 (9.1)	912 (90.9)			89 (8.9)	914 (91.1)		
	≥400	280 (7.7)	29 (10.4)	251 (89.6)			30 (10.7)	250 (89.3)		
Occupation	Employed	2616 (71.4)	294 (11.2)	2322 (88.8)	21.43	<0.001	302 (11.5)	2314 (88.5)	17.03	<0.001
	Unemployed	1047 (28.6)	177 (16.9)	870 (83.1)			174 (16.6)	873 (83.4)		
BMI (kg/m^2)			24.54 ± 3.02	24.79 ± 3.03	2.70	0.10	24.53 ± 3.01	24.79 ± 3.03	3.19	0.07
Self-reported health status	Healthy	1180 (32.2)	94 (8.0)	1086 (92.0)	113.29	<0.001	95 (8.1)	1085 (91.9)	115.45	<0.001
	Average	1330 (36.3)	130 (9.8)	1200 (90.2)			131 (9.8)	1199 (90.2)		
	Unhealthy	1153 (31.5)	248 (21.5)	905 (78.5)			251 (21.8)	902 (78.2)		
Fatigue	Yes	2110 (58.0)	345 (16.4)	1765 (83.6)	51.55	<0.001	351 (16.6)	1759 (83.4)	54.64	<0.001
	No	1527 (42.0)	126 (8.3)	1401 (91.7)			126 (8.3)	1401 (91.7)		
Insomnia	Yes	583 (16.0)	463 (79.4)	120 (20.6)	2791.96	<0.001	467 (80.1)	116 (19.9)	2819.62	<0.001
	No	3070 (84.0)	0 (0.0)	3070 (100.0)			0 (0.0)	3070 (100.0)		
Alcohol	Yes	1763 (48.2)	203 (11.5)	1560 (88.5)	5.87	0.02	213 (12.1)	1550 (87.9)	2.63	0.11
	No	1894 (51.8)	269 (14.2)	1625 (85.8)			263 (13.9)	1631 (86.1)		
Smoking	Yes	916 (25.2)	97 (10.6)	819 (89.4)	5.87	0.02	98 (10.7)	818 (89.3)	5.96	0.02
	No	2724 (74.8)	373 (13.7)	2351 (86.3)			377 (13.8)	2347 (86.2)		
Physical activity	Yes	1482 (41.1)	192 (13.0)	1290 (87.0)	0.01	0.91	201 (13.6)	1281 (86.4)	0.59	0.44
	No	2128 (58.9)	273 (12.8)	1855 (87.2)			270 (12.7)	1858 (87.3)		

BMI, body mass index; WC, waist circumference; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; HDL-C; high density lipoprotein cholesterol.

Table 3. Mean of sleep duration according to the body size phenotypes (n = 3675) (hours).

Division	MHNW[a] (n = 1868)	MANW[b] (n = 148)	MHO[c] (n = 1193)	MAO[d] (n = 466)	Tukey Post hoc analysis	F (*p*)
Sleep duration (hours)	6.76 ± 1.31	7.09 ± 1.39	6.68 ± 1.37	6.72 ± 1.43	b > c, d	3.29 (0.02)

MHNW, metabolically healthy normal weight; MANW, metabolically abnormal but normal weight; MHO, metabolically healthy obesity; MAO, metabolically abnormal obesity. Control variables, education, monthly income, occupation, smoking, physical activity, insomnia.

[a] , MHNW; [b] , MANW; [c] , MHO; [d] , MAO.

unemployed, reported poor subjective health, had fatigue, had insomnia, and did not smoke had more difficulty falling asleep. When compared to difficulty falling asleep, these characteristics showed the same significant differences in difficulty falling back to sleep after waking (Table 2).

3.2 Differences in sleep duration and difficulties according to body size phenotypes

Men with the MANW phenotype slept for the most prolonged duration (7.09 ± 1.39 hours), and men with the MHO phenotype slept for the shortest duration (6.68 ± 1.37 hours). In the Tukey post hoc test, men with the MANW phenotype slept longer than men with the MHO phenotype and men with the MAO phenotype (6.72 ± 1.43 hours) (p = 0.02) (Table 3).

Difficulty falling asleep did not show significant differences according to body size phenotype in any model. Compared to men with the MHNW phenotype, men with the MHO phenotype had less difficulty falling back to sleep after waking, with ORs of 0.77 (p = 0.02) and 0.76 (p = 0.02) in Model 1 and Model 2, respectively (Table 4).

4. Discussion

Studies on the associations between body size phenotypes and their health outcomes have been actively conducted, however, more research has been needed on the effects of body size phenotypes on the sleep quality of middle-aged men. In this study, a population-based analysis examining the difference in sleep quality according to body size phenotype in middle-aged men was carried out.

First, in the results, the sleep duration of MANW men was the longest, and was significantly longer than that for MHO and MAO men. MANW men had a normal sleep duration of over 7 hours, but MHO and MAO men did not. This result suggests that obesity, rather than metabolic health, affects sleep duration [9,13]. Revealing a significantly shorter sleep duration in MHO, a study reporting that an obese group slept fewer than 6 hours [10] was consistent with the findings of this study. For example, in a study of 3158 adults by Singh *et al*. [21], the rate of obesity increased in a group that slept less than 7 to 8 hours compared to a group that slept 7 to 8 hours. In the study by Lopez-Gracia *et al*. [22] in Spain, there was an association with high rate of obesity in a group sleeping less than 5 hours not seen in a group sleeping 8 hours. Although a precise mechanism of a direct association between sleep duration and obesity is unknown, short sleep can lead to obesity. Partial and total sleep deprivation increases cortisol, a hormone closely related to obesity, in the plasma and saliva. Sleep deprivation has been reported to promote weight gain by increasing energy intake through changes in appetite suppressant (leptin) and appetite hormone (ghrelin) concentrations [23].

Adequate sleep duration restores mental and physical function, maintains body homeostasis, and regulates unpleasant emotions experienced during waking hours through dreams and information processing [24]. Lack of sleep time is associated with emotional changes and delayed physical growth [25]. In addition, shorter or longer than adequate sleep duration is associated with a high prevalence of chronic diseases [26]. For example, short sleep increases the relative risk of developing diabetes by 1.57 times [26] and hypertension by 1.20 times [27]. Lack of sleep has been found to be an independent risk factor for type 2 diabetes [28], and in a United States study, a group sleeping for less than 6 hours had a higher risk of hypertension than a group sleeping for 7 hours or more [29].

Therefore, ensuring an adequate sleep duration can be a strategy to reduce obesity, and maintaining a normal weight is essential to reduce the risk of cardiovascular disease, diabetes, hypertension, and eventual mortality for middle-aged men. Counseling and effective intervention programs should focus on the type of men who had a short sleep duration in this study. Middle-aged obesity decreases the quality of sleep, which in turn causes obesity in old age; therefore, long-term health promotion and care are needed in middle-aged men who have difficulty falling asleep or who frequently wake during sleep.

Second, our study provides a new insight, that MHO men have slightly better sleep quality than MHNW men. Compared to MHNW men, MHO men have a 0.76 times risk of difficulty falling back to sleep. This finding differed from the findings of a study reporting that MAO Americans had sleep disorders, had difficulty falling asleep, regularly woke during the night, and felt anxious during sleep [12]. Although the cross-sectional analysis of our study did not show that obesity worsened sleep quality, a longitudinal study in the United States (n = 6850) that tracked BMI and sleep quality in 1965 and 1994 (n = 6850) reported that people's sleep quality generally worsens as their weight status changes from normal weight to obese [30].

Table 4. Sleep disorder according to the body size phenotypes (n = 3675).

Division		Difficulty in falling asleep		Difficulty in falling asleep again	
		Yes		Yes	
		OR (*p*)	95% CI	OR (*p*)	95% CI
Model 1	MHNW	1.0 (reference)		1.0 (reference)	
	MANW	1.07 (0.78)	0.66–1.73	0.91 (0.70)	0.55–1.49
	MHO	0.82 (0.08)	0.66–1.02	0.77 (0.02)	0.61–0.96
	MAO	1.14 (0.36)	0.86–1.52	1.03 (0.82)	0.77–1.38
Model 2	MHNW	1.0 (reference)		1.0 (reference)	
	MANW	0.90 (0.70)	0.54–1.52	0.75 (0.29)	0.44–1.28
	MHO	0.80 (0.07)	0.63–1.01	0.76 (0.02)	0.60–0.96
	MAO	1.02 (0.91)	0.75–1.39	0.93 (0.66)	0.69–1.27
Model 3	MHNW	1.0 (reference)		1.0 (reference)	
	MANW	5.17 (0.12)	0.67–40.10	1.05 (0.94)	0.29–3.77
	MHO	1.11 (0.69)	0.69–1.80	0.90 (0.68)	0.55–1.47
	MAO	1.36 (0.37)	0.70–2.65	0.93 (0.82)	0.49–1.76

MHNW, metabolically healthy normal weight; MANW, metabolically abnormal but normal weight; MHO, metabolically healthy obesity; MAO, metabolically abnormal obesity; CI, confidence interval; OR, odds ratio. Model 1 = no control variable; Model 2 = sleep hard: education (ref = ≥college), monthly income (ref = ≥400), occupation (ref = yes), self-reported health status (ref = healthy), fatigue (ref = no), alcohol (ref = no), smoking (ref = no), Re-sleep hard: education (ref = ≥college), monthly income (ref = ≥400), occupation (ref = yes), self-reported health status (ref = healthy), fatigue (ref = no), smoking (ref = no); Model 3 = Model 2 plus insomnia (ref = no).

People complaining of difficulty falling back to sleep tend to feel worse and more depressed [31]. Poor sleep quality increases the risk of chronic diseases, such as coronary heart disease, cancer, type 2 diabetes, metabolic syndrome, and overweight, and increases the risk of mild mental disorders, such as anxiety and depression [32,33]. In Korea, the number of patients treated for insomnia increased by 37.3% for men and 32.5% for women in 2016 compared to 2012 [34]. Middle-aged men in modern and industrialized societies inevitably suffer from lack of sleep, arbitrarily or involuntarily, in their busy daily lives due to pressing obligations, such as frequent overtime work required for making a living and dinner meetings outside of work [35]. Shift work and irregularly cycled work also reduce sleep quality by inducing changes in the circadian rhythm [36]. Factors that impair sleep quality include shift work history, occupational stress, and lack of healthy behaviors [37,38]. Therefore, these risk factors should be considered to ensure the quality of sleep in middle-aged men.

Diverse measures including obesity management, reducing occupational stress, and providing adequate working conditions should be applied to improve sleep duration and quality of sleep in middle-aged men. Many countries, such as the US, UK, Australia, Japan, and Korea, have implemented health policies and programs to reduce obesity. The Korean government and many of its ministries have also established a strategic plan to mitigate and manage obesity, focusing on diet and physical activities, but not sleep [2]. In our population-based intervention for obesity or metabolic syndrome, we did not pay much attention to sleep as an effective method. To improve the quality of sleep, changes are required not only in lifestyle but also in work conditions (e.g., work hours and commute hours). Interventions in lifestyle and work conditions are critical for middle-aged men because they are the most socially active population group. Individually, they need to understand the importance of sleeping for more than 7 hours per day for their health. At the population level, regulating and monitoring work hours to not exceed 40 hours per week and guaranteeing a 1-hour break time per every 8 hours might be an effective strategy to ensure adequate sleep duration [39].

Additionally, according to the results of univariate analysis in this study, men with high education and income had a problem with sleep duration, and men with low education and income reported difficulty falling asleep and back to sleep. To improve the quality of sleep for individuals with low educational attainment and low income, it is necessary to first carefully assess the risk factors for their sleep disorders. Occupation is an influencing factor that plays a key role in sleep [40,41]. The incidence of sleep problems among those without a job is about four times higher than those with a job [42], and unemployment causes a negative psychological state and sleep problems due to a relatively

low amount of activity [43] and irregular schedules during the daytime hours [44]. This study suggests that efforts to improve sleep quality should be customized according to the socioeconomic status of individuals, such as their employment status, education level, and income.

Several limitations exist with our research. First, due to the use of cross-sectional data, a causal relationship could not be inferred between sleep quality and MHO status. Long-term follow-up studies or country-provided longitudinal research data (e.g., KoGES) could be used. Second, the measurement of sleep duration and difficulties falling asleep depended on self-reported data. Objectively collected data using medical tests, such as polysomnography, cyclic alternating pattern, and actigraphy, could confirm the findings of this study. Third, due to the secondary nature of the data, we could not control variables, such as depression and shift work, affecting sleep and circadian rhythms; future research could include these variables.

5. Conclusions

The purpose of this study was to identify the difference in sleep quality according to body phenotype in middle-aged Korean men. Of 3675 middle-aged men, 45.2% were obese; 16.7% had metabolic syndrome; and 32.5% had an MHO phenotype. The sleep duration of MANW men was longer than that of MHO and MAO men and was normal at over 7 hours (so we failed to reject the null hypothesis 1). Difficulty falling back to sleep after waking occurred 0.76 times less in MHO men than in MHNW men (so we failed to reject the null hypothesis 2).

In conclusion, sleep duration and difficulties falling asleep were independently associated with body size phenotype after adjusting for confounding factors in middle-aged Korean men. Men with an MHO phenotype who were metabolically healthy but had sleep disorders demonstrated a risk of long-term health problems. Physiological changes with age are remarkably diverse and vulnerable, and middle-aged men need an active strategy to promote sleep quality.

Health providers and the officials of ministry of employment and labor may use the results of this study to improve the quality of sleep and ultimately help with productivity in the workplace for middle-aged Korean men. In a community setting, this paper may improve people's, public health providers' and policymakers' awareness of the possible implications of prevention and management of obesity.

Abbreviations

MHNW, metabolically healthy normal weight; MANW, metabolically abnormal but normal weight; MHO, metabolically healthy obesity; MAO, metabolically abnormal obesity; BMI, body mass index; WC, waist circumference; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; HDL-C, high density lipoprotein cholesterol; KoGES, Korean Genome and Epidemiology Study; KCDC, Korea Centers for Disease Control and Prevention.

Author contributions

JYK and YY conceived and designed the study; JYK analyzed the data; JYK, YY and SHB wrote the paper.

Ethics approval and consent to participate

The data was obtained with the approval of the Jeonbuk National University's Institutional Review Board (IRB-No. 2019-10-003-002).

Acknowledgment

The authors acknowledge the KCDC for providing the data of KoGES.

Funding

This research received no external funding.

Conflict of interest

The authors declare no conflict of interest. This research did not receive funding from any funding agency in the public, commercial, or not-for-profit sectors. The authors have no conflict of interest to disclose. The data that support the findings of this study are available from the corresponding author upon reasonable request. The first and corresponding author designed this study, analyzed the data, and wrote the draft. The co-author contributed to the draft.

References

[1] World Health Organization. Fact sheet-obesity-and-overweight 2018. 2020. Available at: https://www.who.int/en/newsroom/fact-sheets/detail/obesity-and-overweight (Accessed: 15 February 2020).

[2] Ministry of Health & Welfare. Ministry of Health & Welfare. Obesity rate. 2020. Available at: https://www.index.go.kr/unify/idx-info.do?idxCd=4239 (Accessed: 5 November 2021).

[3] Blüher M. Are metabolically healthy obese individuals really healthy? Endocrinology. 2014; 171: R209–R219.

[4] Fan J, Song Y, Chen Y, Hui R, Zhang W. Combined effect of obesity and cardio-metabolic abnormality on the risk of cardiovascular disease: a meta-analysis of prospective cohort studies. International Journal of Cardiology. 2013; 168: 4761–4768.

[5] Kramer CK, Zinman B, Retnakaran R. Are metabolically healthy overweight and obesity benign conditions? A systematic review and meta-analysis. Annals of Internal Medicine. 2013; 159: 758–769.

[6] Rey-López JP, de Rezende LF, Pastor-Valero M, Tess BH. The prevalence of metabolically healthy obesity: a systematic review and critical evaluation of the definitions used. Obesity Reviews. 2014; 15: 781–790.

[7] Yoo HK, Choi EY, Park EW, Cheong Y, Bae RA. Comparison of Metabolic Characteristics of Metabolically Healthy but Obese (MHO) Middle-Aged Men According to Different Criteria. Korean Journal of Family Medicine. 2013; 34: 19–26.

[8] Payab M, Hasani-Ranjbar S, Larijani B. Whether all obese subjects both in metabolic groups and non-metabolic groups should

be treated or not. Journal of Diabetes and Metabolic Disorders. 2014; 13: 21.
[9] Vgontzas AN, Liao D, Pejovic S, Calhoun S, Karataraki M, Basta M, *et al*. Insomnia with short sleep duration and mortality: the Penn State cohort. Sleep. 2010; 33: 1159–1164.
[10] Ryu JY, Lee JS, Hong HC, Choi HY, Yoo HJ, Seo JA, *et al*. Association between body size phenotype and sleep duration: Korean National Health and Nutrition Examination Survey V (KNHANES V). Metabolism: Clinical and Experimental. 2015; 64: 460–466.
[11] Sa J, Choe S, Cho BY, Chaput JP, Kim G, Park CH, *et al*. Relationship between sleep and obesity among US and South Korean college students. BMC Public Health. 2020; 20: 96.
[12] Kanagasabai T, Dhanoa R, Kuk JL, Ardern CI. Association between Sleep Habits and Metabolically Healthy Obesity in Adults: a Cross-Sectional Study. Journal of Obesity. 2017; 2017: 5272984.
[13] Hankinson AL, Daviglus ML, Van Horn L, Chan Q, Brown I, Holmes E, *et al*. Diet composition and activity level of at risk and metabolically healthy obese American adults. Obesity. 2013; 21: 637–643.
[14] Spiegel K, Knutson K, Leproult R, Tasali E, Van Cauter E. Sleep loss: a novel risk factor for insulin resistance and Type 2 diabetes. Journal of Applied Physiology. 2005; 99: 2008–2019.
[15] Meisinger C, Heier M, Loewel H. Sleep disturbance as a predictor of type 2 diabetes mellitus in men and women from the general population. Diabetologia. 2005; 48: 235–241.
[16] Lee YW. A Study of Quality of Life in Middle-aged Men. Journal of Korean Academy of Nursing. 2002; 32: 539–549.
[17] Goel N, Kim H, Lao RP. Gender differences in polysomnographic sleep in young healthy sleepers. Chronobiology International. 2005; 22: 905–915.
[18] Kobayashi R, Kohsaka M, Fukuda N, Honma H, Sakakibara S, Koyama T. Gender differences in the sleep of middle-aged individuals. Psychiatry and Clinical Neurosciences. 1998; 52: 186–187.
[19] WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004; 363: 157–163.
[20] Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, *et al*. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation. 2005; 112: 2735–2752.
[21] Singh M, Drake CL, Roehrs T, Hudgel DW, Roth AT. The Association between Obesity and Short Sleep Duration: A Population-Based Study. Journal of Clinical Sleep Medicine. 2005; 1: 357–363.
[22] López-García E, Faubel R, León-Muñoz L, Zuluaga MC, Banegas JR, Rodríguez-Artalejo F. Sleep duration, general and abdominal obesity, and weight change among the older adult population of Spain. The American Journal of Clinical Nutrition. 2008; 87: 310–316.
[23] Chaput JP, Després JP, Bouchard C, Tremblay A. Short sleep duration is associated with reduced leptin levels and increased adiposity: Results from the Quebec family study. Obesity. 2007; 15: 253–261.
[24] Adams J. Socioeconomic position and sleep quantity in UK adults. Journal of Epidemiology & Community Health. 2006; 60: 267–269.
[25] Steptoe A, Peacey V, Wardle J. Sleep duration and health in young adults. Archives of Internal Medicine. 2006; 166: 1689–1692.
[26] Ayas NT, White DP, Al-Delaimy WK, Manson JE, Stampfer MJ, Speizer FE, *et al*. A Prospective Study of Self-Reported Sleep Duration and Incident Diabetes in Women. Diabetes Care. 2003; 26: 380–384.
[27] Wang Q, Xi B, Liu M, Zhang Y, Fu M. Short sleep duration is associated with hypertension risk among adults: a systematic review and meta-analysis. Hypertension Research. 2012; 35: 1012–1018.
[28] Patel SR. Social and demographic factors related to sleep duration. Sleep. 2007; 30: 1077–1078.
[29] Krueger PM, Friedman EM. Sleep duration in the United States: A cross-sectional population-based study. American Journal of Epidemiology. 2009; 169: 1052–1063.
[30] Nordin M, Kaplan RM. Sleep discontinuity and impaired sleep continuity affect transition to and from obesity over time: Results from the Alameda County Study. Scandinavian Journal of Public Health. 2010; 38: 200–207.
[31] Hawes NJ, Wiggins AT, Reed DB, Hardin-Fanning F. Poor sleep quality is associated with obesity and depression in farmers. Public Health Nursing. 2019; 36: 270–275.
[32] Kecklund G, Axelsson J. Health consequences of shift work and insufficient sleep. BMJ-British Medical Journal. 2016; 355: i5210.
[33] Olinto MTA, Garcez A, Henn RL, Macagnan JBA, Paniz VMV, Pattussi MP. Sleep-related problems and minor psychiatric disorders among Brazilian shift workers. Psychiatry Research. 2017; 257: 412–417.
[34] National Health Insurance Service. National Health Insurance Service. Sleepless night insomnia, the number of patients is steadily increasing. 2018 Available at: https://www.nhis.or.kr/nhis/together/wbhaea01600m01.do?mode=view&articleNo=125795&article.offset=0&articleLimit=10&srSearchVal=%EB%B6%88%EB%A9%B4%EC%A6%9D (Accessed: 11 November 2021).
[35] Lee E, Lee KJ. Factors Influencing Sleep Quality among Middle-aged Male Workers. Korean Journal of Occupational Health Nursing. 2014; 23: 235–244.
[36] Ma Y, Wei F, Nie G, Zhang L, Qin J, Peng S, *et al*. Relationship between shift work schedule and self-reported sleep quality in Chinese employees. Chronobiology International. 2018; 35: 261–269.
[37] Jeong JY, Gu MO. Structural Equation Model for Sleep Quality of Female Shift Work Nurses. Journal of Korean Academy of Nursing. 2018; 48: 622–635.
[38] Shin SW, Kim SH. Influence of Health-Promoting Behaviors on Quality of Sleep in Rotating-Shift Nurses. Journal of Korean Academy of Fundamentals of Nursing. 2014; 21: 123–130.
[39] Ministry of Law. Labor Law 2020. 2020. Available at: https://www.law.go.kr/%EB%B2%95%EB%A0%B9/%EA%B7%BC%EB%A1%9C%EA%B8%B0%EC%A4%80%EB%B2%95 (Accessed: 28 February 2020).
[40] Gu D, Sautter J, Pipkin R, Zeng Y. Sociodemographic and health correlates of sleep quality and duration among very old Chinese. Sleep. 2010; 33: 601–610.
[41] Yoon HS, Yang JJ, Song M, Lee H, Han S, Lee S, *et al*. Correlates of self-reported sleep duration in middle-aged and elderly Koreans: from the Health Examinees Study. PLoS ONE. 2015; 10: e0123510.
[42] Choi HJ, Kim BJ, Kim IJ. Prevalence and risk factors of sleep disturbance in community dwelling adults in Korea. Korean Journal of Adult Nursing. 2013; 25: 183–193.
[43] Wu CY, Su TP, Fang CL, Yeh Chang M. Sleep quality among community-dwelling elderly people and its demographic, mental, and physical correlates. Journal of the Chinese Medical Association. 2012; 75: 75–80.
[44] Patel NP, Grandner MA, Xie D, Branas CC, Gooneratne N. "Sleep disparity" in the population: poor sleep quality is strongly associated with poverty and ethnicity. BMC Public Health. 2010; 10: 475.