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Associations of health-related fitness with sleep quality and insomnia in elderly women

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Abstract

This cross-sectional study investigated the associations between health-related fitness and sleep quality and insomnia in 248 elderly women (≥65 years). The Pittsburgh Sleep Quality Index (PSQI) and Insomnia Severity Index (ISI) were used to assess poor sleep quality and insomnia. Health-related fitness was assessed using a senior fitness test protocol. Subjects were classified in the high (high 33%), middle (middle 33%), and low fit (low 33%) groups based on the health-related fitness total Z-scores. Logistic regression analysis was used to estimate odds ratio (OR) and 95% confidence interval (CI) of poor sleep quality and insomnia according to health-related fitness levels. Compared to the high fit group (reference, OR=1), the low fit group had significantly higher OR for having poor sleep quality. Compared to the high fit group (reference, OR=1), the middle fit and low fit group had significantly higher OR for having insomnia. The findings suggest that higher health-related fitness via regular exercise and physical activity can help reduce the risk of poor sleep quality and insomnia in elderly women.

Key words: health-related fitness, sleep quality, insomnia, elderly women

Introduction

Population is aging rapidly worldwide, and this phenomenon of aging is known to increase the prevalence of various forms of sleep-related diseases in addition to chronic degenerative diseases. According to recent national data, the number of Korean adults suffering from insomnia has increased approximately 7.6% in the past five years, and the number of patients with difficulty initiating and maintaining sleep increased by approximately 9.0%; it has been reported that this prevalence rates show an increasing trend that is directly proportional to age (Health Insurance Review & Assessment Service, 2018). Furthermore, reports indicate that the prevalence of sleep disorders is closely related to premature death, and there is an urgent need for preventive measures (Chung et al., 2020).

Sleep is a process by which the brain regenerates and recharges nerve cells through rest after undergoing metabolic activities during the day (Meerlo et al., 2009). Sleep consists of 75 to 80% non-rapid eye movement

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(NREM) sleep and 20 to 25% rapid eye movement (REM) sleep. In old age, people are easily exposed to sleep disorders due to the changes in the ratio of NREM and REM sleep (Ohayon et al., 2004). In addition, as one of the most representative subdomains of sleep disorders, insomnia is known as a condition that involves difficulty falling asleep, staying asleep, or waking up too early (Edinger et al., 2004). The major causes of such sleep disorders are known as stress, medical disorders, neurological disorders, and drug abuse (Patel et al., 2018) while drug therapy with hypnotics, antidepressants, antihistamines, and so on are the most common treatment for sleep disorders (Kim, 2009). However, for drug therapy, the issues with side effects such as dependence, cognitive impairment, falls, and psychomotor retardation have continuously been raised, and research is being conducted on non-pharmacological treatments such as cognitive therapy, stimulus control and sleep restriction (Choi & Lim, 2013; Morin et al., 2004). Accordingly, various studies have reported that physical activity has a positive effect on the prevention of sleep disorders, and a recent study has reported a close association also between physical fitness, the health condition determined by physical activity and health behavior factors, and the risk factors for sleep disorders such as depression and obesity. Thus, the role of physical fitness as a means to prevent sleep disorders in old age is receiving attention (Wang & Boros, 2021; Barcelos-Ferreira et al., 2013; Mendelson et al., 2016; Lee et al., 2014).

Based on long-term studies, the level of fitness in old age has been known to be an independent predictor for major geriatric diseases such as sarcopenia, osteoporosis, falls, and cognitive decline. Furthermore, various studies have reported a close association with the risk factors for sleep disorders such as anxiety, depression, and obesity, leading to active research on the relationship between sleep disorders and physical fitness (Lindegård et al., 2019; Fu et al., 2017). Dishman et al. (2015) and Lee et al. (2018) have reported that the group without sleep problems showed longer duration of exercise stress test and stronger grip strength when the relationship between sleep problems and physical fitness was investigated in adults in the United States and the middle-aged as well as the elderly population in Korea, respectively. Regarding insomnia, Strand et al. (2013) and Lee et al. (2020a) investigated the relationship between physical fitness and insomnia in European geriatric population and older women in Korea, respectively, and reported that higher severity of insomnia was correlated with lower cardiorespiratory fitness and walking function. Based on the findings of these previous studies, it seems that the various levels of fitness in older age can be used as an independent predictor for the quality of sleep and insomnia. However, although various subfactors of physical fitness for promoting health in old age have been suggested, most of the previous research on the relationship between sleep and physical fitness have presented results restricted under the 1-dimensional category of physical fitness. Given the fact that health-related physical fitness including muscle strength, flexibility and cardiorespiratory fitness induces positive effects for healthy aging, it seems necessary to conduct research on the relationships among health-related physical fitness, quality of sleep, and insomnia.

Therefore, the main objective of this study is to provide foundational data on the role of physical fitness as a means to prevent and mitigate sleep disorders in old age through the verification of relationships among health-related physical fitness, quality of sleep, and insomnia in Korean elderly females.

Methods

Participants

This study was conducted with 266 elderly females aged 65 and older living in S-si in Gyeonggi-do, Korea who do not have a particular medical disease, can perform daily life normally, and have consented to participate voluntarily. Once data collection was completed, missing data from 18 participants due to reasons such as physical composition, refusal for measurement of physical fitness, and missing questionnaire were excluded, leaving a total of 248 subjects. All subjects were given a detailed document and verbal explanation on the purpose and the method of this study before signing the participation consent form. This study was conducted after obtaining an approval from the Institutional Review Board of S University (IRB-2015-09-001-002). The characteristics of the subjects are as presented in Table 1.

Methodology

Body composition

Height was measured using an extensometer (DS-102, Jenix, Seoul, Korea). The overall body composition measured as body weight, body fat percentage, and lean mass was measured using Lunar prodigy (GE medical systems Lunar, WI, USA), which uses the principle of dual-energy X-ray absorptiometry (DXA) while subjects changed into clothes without metal substances and were lying on their backs. Body mass index was measured using the formula body weight (kg)/ height (m^2) and waist circumference was measured at the midpoint between the lower rib and the upper iliac crest using an anthropometric tape measure.

Sleep quality

To survey the quality of sleep, the modified and adopted version of the Pittsburgh sleep quality index (PSQI) was used to reflect the cultural situation in Korea (Buysse et al., 2008; Sohn et al., 2012). This questionnaire consists of seven domains including quality of sleep, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping pills, and daytime dysfunction, and each domain is rated as 0 to 3 points. Total score is 21 points and a score of 6 points or higher indicates sleep disorder. In this study, a score

Table 1. *Characteristics of the participants*

Variables	Total (n=248)
Socio-demographic factors	
Age (years)	74.5 ± 7.1
Menopause (years)	49.5 ± 5.5
Education, n (%)	
Less than Elementary	152 (61.3)
Middle/high	89 (35.9)
Over than college	7 (2.8)
Household income, n (%)	
< 100	150 (60.5)
100–300	53 (21.4)
> 300	45 (18.1)
Living status, n (%)	
Living with someone	181 (73.0)
Living alone	67 (27.0)
Body composition	
Height (cm)	151.9 ± 5.1
Weight (kg)	56.8 ± 7.7
BMI (kg/m^2)	24.7 ± 3.2
Body fat (%)	36.7 ± 6.1
WC (cm)	95.0 ± 14.4
Lean mass (kg)	34.3 ± 3.0
Health related factors	
Drinking, n (%)	153 (61.7)
Smoking, n (%)	21 (8.5)
Fall experience, n (%)	64 (25.8)
ADL impaired, n (%)	23 (9.3)
CVD risk factors, n (%)	
1	9 (3.6)
2	46 (18.6)
≥ 3	193 (77.8)
Medications, n (%)	
0	46 (18.5)
1	104 (41.9)
≥ 2	98 (39.6)
MMSE-DS score	24.8 ± 3.9
CES-D score	7.4 ± 9.0

BMI: body mass index, WC: waist circumference, ADL: activities of daily living, CVD: cardiovascular disease, MMSE-DS: mini mental state examination of dementia screening, CES-D: the Center for Epidemiologic Studies Depression Scale of 6 or higher was defined as decreased sleep quality.

Insomnia

To evaluate the degree of insomnia, the Insomnia Severity Index (ISI) was used after being modified and adopted to the circumstances in Korea (Bastien et al., 2001; Cho et al., 2014). This questionnaire consists of seven questions including the severity of the current problem related to insomnia, the current sleep pattern, the degree of interruption in daytime activities due to the sleep disorder, the quality of life, and the self-awareness of the sleep disorder. Each question is scored between 0 (none) and 4 (very severe) points for a total score of 28. Higher scores indicate more severe insomnia whereas scores between 0 to 7 indicate normal, 8 to 15 indicate mild insomnia, 16 to 21 indicate severe insomnia, and 22 or higher indicate severe insomnia. In this study, a score of 8 or higher was defined as insomnia.

Health-related fitness

Health-related fitness was measured based on the senior fitness test (SFT) proposed by Rikli and Jones (2000) by including the factors upper and lower body strength, upper and lower body flexibility, and cardiorespiratory endurance. Upper body strength was measured twice for the left and the right using a dynamometer (TKK-5401, Takei, Niigata, Japan) and the maximum value was used. For lower body strength, the number of times the subject could sit and get up from a chair with arms crossed at the chest was measured for 30 seconds. For upper body flexibility, both arms were placed behind the back and the length of the overlapping middle fingers was measured. For lower body flexibility, the length of both hands extending past the extended leg while the subject was seated in a chair bending over the extended dominant leg with the toes pointing up. Cardiorespiratory endurance was measured as the number of steps taken in the same place for two minutes. In addition, to configure the value representing health-related physical fitness, the measurements for each item were converted to a standardized score (Z-score) to calculate the total score and the group was subdivided into low (low 33%), middle (middle 33%), and high fit (high 33%) groups.

Covariates

As demographic characteristics, menopause, level of education, monthly household income in units of KRW 10,000, and living status were surveyed. As health-related factors, drinking surveyed current drinking habits and smoking was defined as a history of smoking at least five packs in the past or those who are currently smokers (CDC, 1994). For fall experience, the experience of falling in the past one year was surveyed. In activities of daily living (ADL), ADL impaired was defined as answering “partial assistance” to at least one of the questions in the ADL questionnaire (Won et al., 2002). The cardiovascular disease risk factors were surveyed by counting the number of applicable items among hypertension, hyperlipidemia, obesity, sedentary lifestyle, and family history whereas medication counted the number of medications currently being taken. In addition, cognitive function and depressive symptoms were measured using the Korean version of mini-mental state examination of dementia screening (MMSE-DS) and the center for epidemiologic studies depression scale (CES-D) (Kim et al., 2010; Cho & Kim, 1993).

Statistics

All continuous variables in this study were expressed as means and standard deviations, and categorical variables were expressed as percentage for each group. First, the groups were classified based on the PSQI and ISI scores to compare the measurement variables depending on sleep quality and insomnia. An χ^2 test was conducted to check the percentage of measurement variables depending on sleep quality and insomnia for each group while an independent t-test was used to test for the mean differences in the continuous variables. Through binary logistic regression, the odds ratio (OR) for sleep quality deterioration and exposure to insomnia according to health-related fitness level was calculated in a 95% confidence interval (CI). The significance level for hypothesis testing was set to α=0.05, and all statistical analyses were conducted using SPSS-PC (version 23.0).

Results

Comparison of measured variables according to sleep quality and insomnia status

The results of comparing measurement variables according to the quality of sleep and insomnia scores are reported in Table 2. First, when the measurement variables according to sleep quality were compared, the group with PSQI scores of 6 or higher had a significantly higher number of medications being taken (P=0.044) and depression score (P<0.001) compared to the group with a score of less than 6. In addition, when the measurement variables according to insomnia were compared, the group with ISI scores of 8 or higher had significantly lower level of education (P=0.007) and significantly higher depression score (P<0.001) compared to the group with a score of less than 8. There was no significant difference between the groups for the rest of the variables.

Table 2. Comparison of measured variables according to sleep quality and insomnia status

	Sleep quality				Insomnia			
Variables	PSQI < 6 (n=143)	PSQI ≥ 6 (n=105)	t / x^2	P	ISI < 8 (n=173)	ISI ≥ 8 (n=75)	t / x^2	P
PSQI score	3.0±1.4	8.9±2.6	-23.10	<0.001***	4.1±2.6	8.8±3.3	-12.06	<0.001***
ISI score	3.2±3.4	9.9±6.0	-11.18	<0.001***	2.8±2.2	13.4±4.7	-24.19	<0.001***
Socio-demographic factors								
Age (years)	74.2±7.3	74.8±7.0	-0.58	0.562	74.4±7.4	74.6±6.7	-0.16	0.874
Menopause (years)	49.5±5.6	49.5±5.3	0.02	0.988	49.1±5.6	50.5±4.9	-1.92	0.057
Education, n (%)			2.41	0.300			10.01	0.007**
Less than Elementary	82 (57.3)	70 (66.7)			96 (55.5)	56 (74.7)		
Middle/high	56 (39.2)	33 (31.4)			73 (42.2)	16 (21.3)		
Over than college	5 (3.5)	2 (1.9)			4 (2.3)	3 (4.0)		
Household income, n (%)			2.45	0.294			3.93	0.140
<100	81 (56.6)	69 (65.8)			98 (56.6)	52 (69.3)		
100–300	35 (24.5)	18 (17.1)			42 (24.3)	11 (14.7)		
>300	27 (18.9)	18 (17.1)			33 (19.1)	12 (16.0)		
Living status, n (%)			0.21	0.206			0.50	0.481
Living with someone	100 (69.9)	81 (77.1)			124 (71.7)	57 (76.0)		
Living alone	43 (30.1)	24 (22.9)			49 (28.3)	18 (24.0)		
Body composition								
Height (cm)	152.1±4.6	151.6±5.7	0.74	0.463	152.0±5.0	151.5±5.2	0.76	0.449
Weight (kg)	57.0±7.6	56.5±7.9	0.50	0.617	56.8±7.3	56.7±8.5	0.17	0.863
BMI (kg/m2)	24.7±3.3	24.7±3.0	-0.10	0.917	24.6±3.1	24.8±3.3	-0.36	0.722
Body fat (%)	36.9±6.4	36.5±5.7	0.56	0.577	36.7±6.3	36.9±5.8	-0.19	0.849

	Sleep quality				Insomnia			
Variables	PSQI < 6 (n=143)	PSQI ≥ 6 (n=105)	t / x^2	P	ISI < 8 (n=173)	ISI ≥ 8 (n=75)	t / x^2	P
WC (cm)	95.5±14.2	94.2±14.7	0.68	0.496	94.8±14.2	95.3±15.0	-0.25	0.803
Lean mass (kg)	34.2±2.8	34.3±3.3	-0.15	0.881	34.3±2.9	34.1±3.3	0.45	0.657
Health related factors								
Drinking, n (%)	82 (57.3)	71 (67.6)	2.71	0.100	109 (63.0)	44 (58.7)	0.42	0.519
Smoking, n (%)	12 (8.4)	9 (8.6)	0.00	0.960	13 (7.5)	8 (10.7)	0.67	0.413
Fall experience, n (%)	34 (23.8)	30 (28.6)	0.73	0.394	43 (24.9)	21 (28.0)	0.27	0.603
ADL impaired, n (%)	12 (8.4)	11 (10.5)	0.31	0.576	16 (9.2)	7 (9.3)	0.00	0.983
CVD risk factors, n (%)			0.67	0.714			1.25	0.536
1	5 (3.5)	4 (3.8)			5 (2.9)	4 (5.3)		
2	29 (20.3)	17 (16.2)			34 (19.6)	12 (16.0)		
≥3	109 (76.2)	84 (80.0)			134 (77.5)	59 (78.7)		
Medications, n (%)			6.26	0.044*			2.75	0.253
0	26 (18.2)	20 (19.0)			32 (18.5)	14 (18.7)		
1	69 (48.3)	35 (33.3)			78 (45.1)	26 (34.7)		
≥2	48 (33.5)	50 (47.7)			63 (36.4)	35 (46.6)		
MMSE-DS score	25.0±3.8	24.5±4.0	0.89	0.376	24.8±4.2	24.8±3.2	-0.01	0.997
CES-D score	4.6±6.0	11.3±10.9	-6.20	<0.001***	5.0±6.3	13.1±11.6	-7.11	<0.001***

PSQI: Pittsburgh Sleep Quality Index, ISI: Insomnia Severity Index, BMI: body mass index, WC: waist circumference, ADL: activities of daily living, CVD: cardiovascular disease, MMSE-DS: mini mental state examination of dementia screening, CES-D: the Center for Epidemiologic Studies Depression Scale
*, **, and *** indicate P<0.05, P<0.01, and P<0.001, respectively.

***Table 3**. Comparison of health-related fitness according to sleep quality and insomnia status*

	Sleep quality				Insomnia			
Variables	PSQI < 6 (n=143)	PSQI ≥ 6 (n=105)	t	P	ISI < 8 (n=173)	ISI ≥ 8 (n=75)	t	P
Upper body strength (kg)	19.5±4.8	17.4±5.0	3.32	0.001**	19.3±5.2	16.8±4.0	3.68	<0.001***
Lower body strength (times/30sec)	14.7±4.3	13.2±4.1	2.77	0.006**	14.6±4.5	12.8±3.4	3.11	0.002**
Upper body flexibility (cm)	-11.3±12.7	-11.9±13.3	0.36	0.723	-11.0±13.0	-12.8±12.8	1.03	0.305
Lower body flexibility (cm)	10.7±9.6	9.0±10.5	1.35	0.178	10.4±10.1	9.1±9.8	0.93	0.351
Cardiorespiratory endurance (times/2min)	100.5±14.5	93.2±17.8	3.48	0.001**	100.7±14.4	89.9±18.3	4.84	<0.001***
Total Z-score	0.144±0.584	-0.142±0.603	3.65	<0.001***	0.140±0.585	-0.249±0.576	4.69	<0.001***

PSQI: Pittsburgh Sleep Quality Index, ISI: Insomnia Severity Index
*, **, and *** indicate P<0.05, P<0.01, and P<0.001, respectively.

Comparison of health-related fitness according to sleep quality and insomnia status

The results of comparing health-related physical fitness according to sleep quality and insomnia scores are presented in Table 3. When the health-related physical fitness according to sleep quality was compared, the groups with PSQI scores of 6 or higher showed significantly lower upper body strength (P=0.001), lower body strength (P=0.006), and cardiorespiratory endurance (P=0.001) compared to the group with a score of less than 6. When health-related physical fitness according insomnia was compared, the group with an ISI score of 8 or higher showed significantly lower upper body strength (P<0.001), lower body strength (P=0.002), and cardiorespiratory endurance (P<0.001) compared to the group with a score of less than 8.

Odds ratio of poor sleep quality and insomnia according to health-related fitness levels

The results of calculating the OR of exposure to sleep quality deterioration and insomnia according to health-related fitness levels are shown in Table 4. First, as a result of calculating the aforementioned OR according to the physical fitness level, the low fit group (OR=3.710, 95% CI=1.894-7.266, P=0.001) were found to have a significantly higher risk of being exposed to sleep quality deterioration compared to the high fit group (reference=1). This inter-group difference was still significant in the Model 1 (OR=3.828, 95% CI=1.799-8.144, P<0.001), Model 2 (OR=3.990, 95% CI=1.823-8.733, P=0.001), and Model 3 (OR=2.682, 95% CI=1.119-6.429, P=0.027) in which the covariates were modified stepwise.

In addition, as a result of calculating the OR of exposure to insomnia according to the physical fitness level, the middle fit group (OR=2.407, 95% CI=1.102-5.258, P=0.028) and the low fit group (OR=4.514, 95% CI=2.107-9.670, P<0.001) were found to be significantly less likely to be exposed to insomnia compared to the high fit group (reference=1). This intergroup difference was still significant in Model 1 (middle fit: OR=2.370, 95% CI=1.031-5.449, P=0.042; low fit: OR=5.131, 95% CI=2.145-12.273, P<0.001), Model 2 (middle fit: OR=2.407, 95% CI=1.023-5.665, P=0.044; low fit: OR=5.133, 95% CI=2.089-12.616, P<0.001), and Model 3 (low fit: OR=4.314, 95% CI=1.538-12.099, P=0.005) even after the stepwise modification of covariates.

Discussion

This study was conducted with the main objective of examining the relationships among health-related physical fitness, quality of sleep, and insomnia in Korean female elderly. To do so, subjects were classified into the high, middle, and low fit groups depending on their level of health-related physical fitness, and the risk of being exposed to sleep quality deterioration and insomnia was calculated. Lower level of physical fitness was found to be associated with significantly higher risk of exposure to sleep quality deterioration and insomnia.

As interest for geriatric diseases is increasing in line with the aging population, national large-scale epidemiological survey indicates that approximately 41.9% of the elderly in Korea experience sleep quality deterioration and the prevalence of insomnia is found to be approximately 20.1%. As such, interest for geriatric sleep-related problems is increasing (Health Insurance Review & Assessment Service, 2018; Kwon & Shin, 2016). When the prevalence of sleep quality deterioration and insomnia in elderly females in regional communities was examined and calculated, it was found to be 42.3% for sleep quality deterioration and 30.2% for insomnia, with the prevalence of insomnia somewhat higher than the results of the national large-scale survey. These findings can be attributed to the fact that the subjects of this study were restricted to females, who were vulnerable to sleep disorders, and that they were

Table 4. Odds ratio of poor sleep quality and insomnia according to health-related fitness levels

	OR (95% CI)							
	Model 0	P value	Model 1	P value	Model 2	P value	Model 3	P value
Poor sleep quality								
High fit	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Middle fit	1.739 (0.891-3.396)	0.105	1.730 (0.854-3.504)	0.128	1.833 (0.883-3.804)	0.104	1.272 (0.569-2.843)	0.557
Low fit	3.710 (1.894-7.266)	<0.001***	3.828 (1.799-8.144)	<0.001***	3.990 (1.823-8.733)	0.001**	2.682 (1.119-6.429)	0.027*
Insomnia								
High fit	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Middle fit	2.407 (1.102-5.258)	0.028*	2.370 (1.031-5.449)	0.042*	2.407 (1.023-5.665)	0.044*	1.956 (0.743-5.151)	0.175
Low fit	4.514 (2.107-9.670)	<0.001***	5.131 (2.145-12.273)	<0.001***	5.133 (2.089-12.616)	<0.001***	4.314 (1.538-12.099)	0.005**

Model 0 was unadjusted
Model 1 was Model 0 plus socio-demographic factors (i.e., age, menopause, education, household income, and living status)
Model 2 was Model 1 plus body composition parameters (i.e., BMI, body fat, WC, and lean mass)
Model 3 was Model 2 plus health-related factors (i.e., drinking, smoking, fall experience, ADL impaired, CVD risk factors, medications, MMSE, and CES-D
OR: odd ratio, CI: confidence interval, BMI: body mass index, WC: waist circumference, ADL: activities of daily living, CVD: cardiovascular disease, MMSE: mini mental state examination of dementia screening, CES-D: the Center for Epidemiologic Studies Depression Scale
*, **, and *** indicate $P<0.05$, $P<0.01$, and $P<0.001$, respectively.

older than the subjects surveyed in the national large-scale epidemiological survey (La et al., 2020).

Common risk factors of sleep disorders in old age are known to include mental factors such as stress, neurological disorders, and anxiety, and physical factors such as pain, obesity, physical disability, and chronic diseases (Zaidel et al., 2021). Persistent sleep problems are even known to cause premature death through falls, depression, and cognitive decline (Chung et al., 2020; Stone & Xiao, 2018). As such, various studies have reported that the level of physical fitness in old age is not only closely related to the risk factors for sleep disorders but also to have a positive effect on the improvement of sleep quality and insomnia in old age (Mendelson et al., 2016; Lee et al., 2020a). However, while results are being continuously reported on the one-dimensional role of physical fitness such as muscle strength and cardiorespiratory endurance in sleep problems in old age, there are very few studies on the relationship between health-related physical fitness and sleep problems in old age. Hence, the current study compared the components of health-related physical fitness based on the scores of sleep quality and insomnia and the results indicated that upper body strength, lower body strength, and cardiorespiratory endurance were significantly lower in the group with decreased sleep quality and insomnia, with significantly lower standardized scores for health-related physical fitness.

These results are consistent with the results of Hsu et al. (2021), who examined the relationships among sleep quality, chronic diseases and health-related physical fitness in middle-aged and elderly Asians and reported that health-related physical fitness such as flexibility, cardiorespiratory endurance, and balance were related to sleep quality along with chronic disease, and the results of Reyes et al. (2013), who investigated the relationship between sleep patterns and physical functioning in South American elderly population and reported that physical functioning was significantly higher in the group showing appropriate sleep duration and sleep patterns. Based on the results of the current and previous studies, health-related physical fitness in old age is not only closely related to the quality of sleep and appropriate sleep behavior but can also be interpreted in the similar context as studies that reported sleep problems can be alleviated by inducing positive effects for the factors that interfere with sleep such as chronic diseases, life habits, and anxiety (Strand et al., 2013; Lee et al., 2020b).

In addition, when the OR of being exposed to sleep quality deterioration and insomnia was calculated based on the standardized score for health-related physical fitness, the risk of being exposed to sleep quality deterioration and insomnia was found to be higher for lower level of physical fitness, and the significant difference in the risk of exposure to sleep quality deterioration and insomnia according to physical fitness level was still present even in the models with stepwise modification of covariates. These results are consistent with the findings of Peng et al. (2019), who studied the relationship between physical fitness and sleep quality in 1136 Asian middle-aged and elderly subjects and reported that the risk of being exposed to sleep quality deterioration was higher for lower level of overall physical fitness such as lung capacity and balance. They are also consistent with the results of Moreno-Vecino et al. (2017), who studied 463 European female elderly on the relationship between sleep disorders and physical fitness and reported that the group with higher physical fitness had lower risk of exposure to sleep disorders and reported improvement in health-related quality of life that was decreased by sleep disorders. Based on these findings, the level of physical fitness in old age is not only closely related to the various types of sleep problems such as sleep duration, sleep quality, and insomnia but can also act as the factors that could modify the health condition that has become worse due to sleep problems as reported by previous studies (Mendelson et al., 2016; Spira et al., 2014). Ultimately, this means that they can be key factors in improving and preventing health-related deterioration in quality of life due to sleep problems in old age.

However, this study has several limitations as follows. First, the subjects were restricted to female elderly and it is necessary for future studies to include males and subjects from various age groups to verify the role of health-related physical fitness in the sleep problems for various groups. Second, as the study restricted the definition of sleep quality and insomnia to the questionnaire alone, it seems necessary to conduct an objective verification of the role of physical fitness in future studies through measurements and survey by a specialized institution to diagnose sleep disorders. Third, due to the nature of the design of this study, there is limitation in explaining the causal relationship between physical fitness and sleep problems. Therefore, in future studies, it is necessary to verify the causal relationship between physical fitness and sleep problems in old age through a longitudinal design.

Conclusion

Taken together, the results of this study suggest that the health-related physical fitness in elderly females has a significant relationship with sleep quality and insomnia. Furthermore, it seems that promoting health-related physical fitness through regular physical activities and exercise may be an effective strategy to prevent and delay sleep problems in old age.

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