Original Research

Sleep Quality and Cognitive Function in the Elderly Population

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Received: 09 Sep. 2019 Accepted: 01 Dec. 2019

Abstract

Background and Objective: Physiological process of sleep is considered as one of the influential factors of human's health and mental functions, especially in the elderly. This research aimed at studying the association between sleep quality and the cognitive functions in the elderly population.

Materials and Methods: A total of 200 elderly people (65 years and older) who were the members of retirees association in Mashhad, Iran, participated in this cross-sectional study. The participants were asked to answer the questionnaire of Pittsburgh Sleep Quality Index (PSQI) and Montreal Cognitive Assessment (MoCA) test. Correlation between the total scores of PSQI and MoCA was evaluated by Pearson correlation coefficient. In order to predict the cognitive function based on different aspects of PSQI, multiple regression analysis by hierarchical method was used after removing confounding variables.

Results: A significant association was found between PSQI and MoCA ($P < 0.001$, $r = -0.55$) suggesting that the components of use of sleeping medication ($P < 0.001$, $r = -0.47$), sleep disorders ($P < 0.001$, $r = -0.37$), sleep latency ($P < 0.001$, $r = -0.34$), subjective sleep quality ($P < 0.001$, $r = -0.32$), sleep duration ($P < 0.001$, $r = -0.27$), sleep efficiency ($P < 0.001$, $r = -0.26$), and daytime dysfunction ($P < 0.001$, $r = -0.15$) had significant negative correlation with cognitive function, and the four components of subjective sleep quality ($P = 0.010$, $\beta = -0.15$), sleep latency ($P = 0.040$, $\beta = -0.13$), sleep disorders ($P = 0.010$, $\beta = -0.26$), and use of sleeping medication ($P = 0.010$, $\beta = -0.26$) played a role in prediction of cognitive function in regression analysis.

Conclusion: Poor sleep quality, sleep latency, insomnia, sleep breathing disorder, and use of sleeping medication play a determining role in cognitive function of the elderly. Thus, taking care of the sleep health is necessary for the elderly.

Keywords: Sleep hygiene; Cognition; Frail elderly

Citation: Mousavi SV, Montazar E, Rezaei S, Poorabolghasem Hosseini S. **Sleep Quality and Cognitive Function in the Elderly Population.** J Sleep Sci 2020; 5(1): 20-27.

Introduction

Aging is a process accompanied by deep changes of the human's physiological and psychological aspects (1). In this period of life, humans are exposed to various physiological illnesses with clinical manifestations such as cardiovascular diseases (CVDs), depression, amnesia, and sleep problems. In this regards, low quality of sleep is the third problem of the elderly after headache and digestive disorders (1, 2). Sleeping is a necessary physiological process that helps the repairing functions and provides the energy needed for daily activities (3, 4).

The elderly experience short sleep, high frequency of waking up during night, and daily sleep more often, and they wake up at the morning earlier than the usual time (3, 5, 6). Poor sleep quality among the elderly (above 60 years old) can occur due to aging, primary sleep disorders, chronic stress, nightly worries, unfavorable situation, physical and mental illnesses, taking medicines, and social-mental factors (7-9). These can lead to unfavorable health consequences such as death, cardiac diseases, anxiety and depression disorders, falling, accident, disturbed cognitive function, and reduced performance and quality of life (7-9).

As sleep problems are prevalent among the adults, some levels of decreased cognitive func-

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tion are also a part of aging process for most people (10). Changes in cognitive functions such as reaction time, sensory processing, attention, memory, reasoning, and executive functions are also the results of aging among the elderly (11). Aging and senility lead to reduced sleep quality and cognitive functions among the elderly, and the lower sleep quality per se increases the deficiency of cognitive functions (5).

The research conducted by Tsapanou et al. (12) indicated that poor sleep quality was related to poor memory score, and the research conducted by Liu et al. (3) indicated that insufficient sleep was correlated to poor cognitive function. The research conducted by Niu et al. (13) investigated the association between sleep quality and cognitive functions among the elderly and indicated that people with poor sleep quality had a significantly lower cognitive function compared to the people with appropriate sleep quality. These results indicate that low sleep quality has an association with poor cognitive functions. On the other hand, some findings do not suggest any association between sleep pattern and cognitive function, and this has made this fact uncertain that whether unfavorable sleep quality leads to cognitive problems. In the research conducted by Merlino et al. (14), insomnia as the most frequent sleep complaint in older Italian adults, had no association with the presence of cognitive decline. Contrary to insomnia, excessive daytime sleepiness (EDS) was significantly associated to dementia (and especially memory domain) among the elderly more than 65 years old. Furthermore, the research conducted by Foley et al. (15) suggests that the persons reporting EDS are twice as likely to be diagnosed with incident dementia as individuals not reporting daytime sleepiness. Conversely, insomnia had no relationship with cognitive decline or incidence of dementia. Also, the findings of the research conducted by Saint Martin et al. (16) and Blackwell et al. (17) indicated that there was no correlation between the reported quality of life and the cognitive measure; but a closer look on their results reveals that in non-patient elders, subjective sleep quality and period did not significantly impact on subjective and objective cognitive performances, except the attention level (16). Moreover, there was no association between sleep quality and cognitive components including orientation, concentration, language, and recent and long-term memory (16).

Due to the inconsistent results in previous research and the role and importance of sleep quality in daily life and cognitive activities, further research is needed to understand the importance of this topic; thus, we seek to use the findings of this study in sleep enhancement and functional use programs in the elderly. Therefore, this research aimed at studying the association between sleep quality and cognitive functions of the elderly population. The research hypothesis is that there is a relationship between sleep quality and cognitive functions among the elderly. In order to expand our knowledge about the role of sleep and its components in cognitive functions, we investigated association of different components of sleep quality based on Pittsburgh Sleep Quality Index (PSQI) with cognitive functions.

Materials and Methods

Participants

This research was a descriptive cross-sectional study. The research population consisted of all the elderly > 65 years old who were members of retirees association in Mashhad, Iran, in 2016-2017. A total of 200 participants (97 men and 103 women) were selected by purposive sampling. In order to determine the sample size for at most 10 independent variables in the predictive variable (seven subscales of PSQI) and at most three covariance variables (age, gender, and education level) we used F test set of G*Power 3.1.9.2 software. Considering the type I error (alpha) at 0.01 level (confidence level of 0.99), test power equal to 0.95, and the average effect size as $f^2 = 0.15$, the sample size was obtained equal to 200 participants (18). The inclusion criteria were the age between 65 and 90 years, willingness to answer the questions, informed consent, having no cognitive disorders (such as dementia, Alzheimer, and vascular dementia) based on an available medical file, and no affliction to acute physical-mental illnesses. The exclusion criteria included lack of cooperation, severe speech problems, severe hearing problems without using hearing aid, and vision problems without using glasses.

For ethical approval of the research, all the research participants filled the consent letter before entering the study. All procedures carried out in studies implicating human participants were in accordance with the ethical standards of the institutional and/or national research committee and the Declaration of Helsinki (1964) and its later amendments or similar ethical standards. This article does not encompass any study on animals conducted by any of the authors.

Pittsburg Sleep Quality Index (PSQI)

This self-reporting scale consists of 19 items in the scales of subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency (efficient sleep), sleep disorders (including breathing problems and feeling pain), use of sleeping medication, and daytime dysfunction. Each item has a score of 0 to 3. The score scope ranges from 0 to 21. The more the score is, the lower the sleep quality is, and a total score of more than 5 indicates poor sleep quality (5). In Iran, this questionnaire has been used in different populations and its psychometric properties have been reported as being acceptable (Cronbach's alpha: 0.89-0.93) (19).

Montreal Cognitive Assessment (MoCA) test

This tool is a cognitive screening questionnaire that measures eight cognitive areas through different skills including short-term memory, visual-spatial skills, executive functions, attention, concentration, working memory, language, and awareness of time and place. The highest score of this test is 30 and the score 26 or higher indicates a normal situation of cognitive function (20). In this research, we used only the total score of MoCA. In Iran, in the research conducted by Emsaki et al. (21) to measure the psychometric properties of this scale, Cronbach's alpha coefficient was obtained as 0.77, concurrent validity as 0.79, sensitivity as 0.85, and the feature as 0.90.

Statistical analysis

Pearson correlation coefficient (r) was used to investigate the correlation between sleep quality and its different aspects with cognitive functions. Furthermore, the hierarchical multiple regression was used to determine which components of sleep quality are related to cognitive functions after removing the confounding variables. Before doing the regression analysis, the assumption of normality of the criterion variable was studied by histogram diagram and matching it with the normal curve. The assumption of independency of errors was studied by Durbin-Watson (DW) test, and assumption of multicollinearity of the predictive variables was studied by the statistics of tolerance and inflation of variance. Independent student's t-test was used to compare the cognitive functions among men and women. SPSS software (version 20, IBM Corporation, Armonk, NY, USA) was used to analyze the results. Significance level was considered as $P < 0.05$.

Results

In this research, 97 men and 103 women answered the questionnaires with the average age of 65.95 and 66.02 years, respectively. The average level of education (number of years spent in education) was obtained for men 6.10 ± 2.79 and for women 6.27 ± 2.70, in which no significant differences were observed in the two groups [t = 0.430, degree of freedom (df) = 198, P = 0.665]. A significant positive association was found between cognitive functions and age (P = 0.018), but not between cognitive functions and education level (P = 0.306); accordingly with the growing of age, the scores of cognitive functions significantly decreased. However, in the elderly sample of this study, education level did not have any significant relationship with cognitive functions. The results of independent student's t-test for determining the difference between the averages of cognitive functions in men and women suggested no significant difference (P = 0.638, df = 198, t = 0.471). Only the age variable was statistically controlled as covariate in hierarchical regression analysis. Table 1 indicates the descriptive statistics of the subscales of PSQI and total score of MoCA.

Table 1. Mean and standard deviation (SD) of Pittsburgh Sleep Quality Index (PSQI) and Montreal Cognitive Assessment (MoCA) variables

Variables	Gender	Mean ± SD
Subjective sleep quality	Women	1.35 ± 1.00
	Men	1.26 ± 1.03
Sleep latency	Women	1.31 ± 1.10
	Men	1.26 ± 0.95
Sleep duration	Women	1.47 ± 0.99
	Men	1.53 ± 0.86
Habitual sleep efficiency	Women	1.41 ± 0.92
	Men	1.46 ± 1.04
Sleep disturbances	Women	1.17 ± 0.98
	Men	1.08 ± 1.00
Use of sleeping medications	Women	1.01 ± 0.89
	Men	1.06 ± 0.89
Daytime dysfunction	Women	1.45 ± 1.00
	Men	1.23 ± 0.97
PSQI total score	Women	9.21 ± 3.77
	Men	8.91 ± 3.66
Moca total score	Women	19.38 ± 7.56
	Men	18.84 ± 8.70

SD: Standard deviation; PSQI: Pittsburgh Sleep Quality Index; MoCA: Montreal Cognitive Assessment

The correlation coefficients indicated that there was a significant negative relationship between sleep quality and cognitive function ($P < 0.001$, $r = -0.55$). With increasing PSQI score (lower sleep quality), MoCA scores decreased.

The association of mental quality of sleep (r: -0.32), sleep latency (-0.34), sleep duration (r: -0.26), sleep efficiency (-0.26), sleep disorders (r: -0.37), sleeping medications (r: -0.41), performance disorders (r: -0.15), and the total sleep quality (r: -0.55) with the cognitive function was a significant negative relationship at 0.01 level (Table 2).

Hierarchical multiple regression analysis was used to predict the cognitive function based on the components of PSQI. Before conducting analysis, first, the assumption of normality of the criterion variable in regression analysis of the total score of the cognitive function by the histogram diagram of the standardized residuals and its matching with the normal curve was studied. It was found that the standardized remaining of the regression of the total scores of cognitive function followed a normal distribution.

Furthermore, the normal P-P plot indicated that the observed cumulative probability or the points suggesting the standardized remaining of the criterion variable were near the normal line (expressing the normal distribution). Therefore, it can be found that deviation of the criterion variable data (MoCA scores) from the normal distribution is little.

In addition, the results of DW test (DW = 1.937) indicated that the assumption of independency of the errors for execution of regression analysis was approved. Table 3 presents a study of assumptions indices of multicollinearity between the predictive variable (sleep quality components) and the results of hierarchical regression analysis after controlling the confounding variable of age.

According to the table 3, the statistics of variance tolerance and inflation of multicollinearity of the variables was rejected [tolerance > 0.4, variance inflation factor (VIF) < 2]. Therefore, regression analysis can be used. According to the results of table 3, the variables of age and PSQI components predicted cognitive functions. Age and sleep quality components predicted 3% and 34% of MoCA changes, respectively. Of 7 components of PSQI, subjective sleep quality ($P = 0.010$, $\beta = -0.15$), sleep latency ($P = 0.040$, $\beta = -0.13$), sleep disorders ($P = 0.001$, $\beta = -0.26$), and using sleeping medications ($P = 0.010$, $\beta = -0.26$) had a determining role in predicting the cognitive function (Table 3).

Discussion

The results of this study indicated a significant and strong negative relationship between sleep quality and cognitive function in the elderly. Thus, the lower the sleep quality in the elderly is, the poorer the cognitive function is. The studies conducted by Waller et al. (5), Liu et al (3), Niu et al (13), and Chen et al. (22) indicated that people with poorer sleep quality had lower scores of cognitive function. The research conducted by Cricco et al. (23) indicated that sleep problems and insomnia were correlated to decreased cognitive function in the elderly.

The elderly with poor sleep quality had a poorer performance in the tests of working memory, attention shifting, and abstract problem solving in terms of processing speed, recognition function, and implicit memory (24), and it suggests that insufficient sleep will influence the cognitive functions that require more concentration. In this research, the elderly with lower sleep quality got lower scores in total cognitive function (based on MoCA test including assignments such as short-term memory, visual-spatial skills, executive functions, attention and concentration, working memory, language, and awareness of time and place).

Table 2. Correlation coefficients of the research variables in the elderly

Variables	1*	2	3	4	5	6	7	8	9	10	11
MoCA total score (1)	1										
Age (2)	-0.168*	1									
Education level (3)	-0.073	-0.288**	1								
PSQI total score (4)	-0.555**	0.057	0.059	1							
Subjective sleep quality (5)	-0.318**	0.082	-0.156*	0.548**	1						
Sleep latency (6)	-0.341**	0.039	0.087	0.642**	0.271**	1					
Sleep duration (7)	-0.267**	-0.022	0.141*	0.521**	0.148*	0.244**	1				
Habitual sleep efficiency (8)	-0.262**	0.102	-0.018	0.547**	0.192**	0.271**	0.189**	1			
Sleep disturbances (9)	-0.368**	-0.025	0.074	0.528**	0.118	0.203**	0.129	0.152*	1		
Use of sleeping medications (10)	-0.407**	0.082	0.095	0.509**	0.201**	0.227**	0.216**	0.134	0.141*	1	
Daytime dysfunction (11)	-0.151*	-0.043	0.018	0.492**	0.113	0.180*	0.090	0.130	0.243**	0.086	1

Numbers represent research variables in the elderly

*P < 0.05; **P < 0.01; PSQI: Pittsburgh Sleep Quality Index; MoCA: Montreal Cognitive Assessment

Table 3. Hierarchical regression of Montreal Cognitive Assessment (MoCA) based on Pittsburgh Sleep Quality Index (PSQI) components

Steps	Predictors	R^2	R^2 change	F-value	β	P-value	Tolerance	VIF
1	Age	0.03	0.03	5.73				
					-0.17	0.0200	0.97	0.02
2	Final (corrected) model	0.37	0.34	14.08	-0.13	0.0300		
	Age				-0.13	0.0300	0.97	0.02
	Subjective sleep quality				-0.15	0.0100	0.88	1.13
	Sleep latency				-0.13	0.0400	0.81	1.23
	Sleep duration				-0.11	0.0800	0.89	1.12
	Habitual sleep efficiency				-0.09	0.1600	0.87	1.13
	Sleep disturbances				-0.26	0.0001	0.89	1.11
	Use of sleeping medications				-0.26	0.0001	0.89	1.12
	Daytime dysfunction				-0.01	0.8800	0.91	1.09

VIF: Variance inflation factor

All the aspects of sleep quality had a significant negative association with cognitive function. Subjective sleep quality had a significant negative relationship with cognitive function and it suggests that there is a relationship between one's subjective assessment of own sleep and own cognitive performance. Although subjective measurement of sleep quality presents a general estimation of sleep quality, some researchers have found a significant relationship between subjective sleep quality and cognitive function in the elderly, suggesting that the preserved attention, reaction time, and memory are influenced by sleep quality (10).

There was also a significant negative relationship between sleep latency and cognitive performance. Furthermore, this component had an important role in predicting the cognitive function in the elderly and it suggests that with aging, the elderly spend more time on sleep and they really sleep for a less time. It indicates the increased sleep latency and delay in falling asleep (25). The research conducted by Schmutte et al. (26) in the field indicated that the decreased performance of language knowledge, long-term memory as well as visual-spatial reasoning had a relationship with longer sleep latency.

On the other hand, sleep efficiency is the actual duration of sleep that decreases with aging. In this field, the results indicated a significant negative relationship between sleep efficiency and cognitive function in the elderly. The study of Potvin et al. (27) also showed that short duration of sleep had a correlation with damage to cognitive function in men, and long duration of sleep had a correlation with damage to cognitive function in women. In the results of this research, no significant difference was observed between cognitive function in men and women. Additionally, the duration of efficient sleep in the elderly is important. A group of the elderly report longer or shorter sleep duration than the usual duration of 7 to 9 hours.

The studies conducted by Schmutte et al. (26), Blackwell et al. (17), Faubel et al. (28), and Ramos et al. (29) indicated that sleep duration of longer than nine hours was correlated to poor cognitive function. Whereas, the studies conducted by Xu et al. (30), Ferrie et al. (31), Virta et al. (32), and Devore et al. (33) showed that there was a correlation between short sleep duration (3 to 4 hours) and long sleep duration (more than 10 hours) with memory problems. Therefore, it can be stated that short sleep less than 4 hours, due to insufficiency, and long sleep more than 10 hours, due to inefficiency, are both related to damage to cognitive function.

The relationship between sleep disorders and poor cognitive functions was significant in this study. In this research, sleep disorders had an important role in explaining cognitive function. Insomnia and sleep-disordered breathing (SDB), as the most prevalent sleep disorders in the elderly, can influence the cognitive function in the elderly (6, 23). The results of the study conducted by Haimov et al. (34) showed that insomnia played a role in memory span problems and executive functions. However, it has not had a major role in easy attention assignments, the cause of which can be higher provocation which is a characteristic of people with insomnia. Of course, since more cognitive sources are needed in complicated assignments, they will face with problem. Also, some research suggests the correlation between SDB and the general cognitive function but not all the cognitive aspects, and this mainly influences three aspects of awareness, executive functions, and memory (35, 36). The research conducted by Martin et al. (37) points to the destructive long-term effects of SDB on cognitive function of the elderly which indicates the serious effects of this disorder on cognitive actions in the elderly.

Current results suggested that use of sleeping medications had a relationship with cognitive functions and it was considered as one of the components explaining cognitive functions. Most of the elderly who are faced with sleep disorders use sleeping medications. These drugs decrease sleep periods with rapid eye movements and so influence their cognitive function. Calmatives and sleeping medications such as benzodiazepines (BDZs) including diazepam and flurazepam play an important role in cognitive problems and confusion in the elderly (38). According to the results, daytime dysfunction caused by sleep problems is related to cognitive function, and daytime dysfunction has a negative and significant correlation with decreased cognitive function in the elderly. In this regards, Yaffe et al. (39) and Barnes and Yaffe (40) indicated that daily sleep, decreased concentration, and tiredness were the consequences of poor sleep quality in the elderly which disturb the daily functions and might increase the cognitive deficiency.

According to the results of correlation between sleep quality aspects with cognitive function, the components of sleep disorders and using sleeping medications have the strongest association with the cognitive function in the elderly and an explanatory role. Sleep disorders like insomnia and SDB are more observed in the elderly. SDB with periodic obstruction of airways, intermittent decrease of blood oxygen at night, and interrupted nightly sleep leads to insomnia and disturbance in cognitive functions such as awareness, attention, reaction time, executive function, problem solving, retrieval, and memory. The elderly may use sleeping medications to counter sleep disorders. On the one hand, these drugs improve the quality of nightly sleep by their biological effects, and on the other hand, they are accompanied with side effects such as confusion, amnesia, and perception and cognitive problems.

The research population was only related to the retirees associations (and it does not include the elderly residing at nursing homes). This research was of correlation type and it does not provide the possibility of cause-effect inference for us.

Regarding the results of the research, it can be stated that there is a significant relationship between sleep quality and cognitive function in the elderly. The predictive role of some components of sleep quality such as subjective sleep quality, sleep latency, sleep disorders, and using sleeping medications suggests the necessity of conducting research studying how they play their role in cognitive functions, and presenting plans for improving sleep quality and studying its effects on cognitive functions in the elderly. Sleep and cognitive functions both have descending changes with aging. This suggests the association and correlation between these two variables and predictability of cognitive function based on sleep quality. The results of this research indicate that enough and good quality sleep improves the cognitive function and probably life quality of the elderly.

Conclusion

Poor sleep quality, sleep latency, insomnia, sleep breathing disorder, and use of sleeping medication play a determining role in cognitive function of the elderly. Thus, taking care of the sleep health is necessary for the elderly. In order to improve the cognitive function in the elderly that leads to increased well-being and interpersonal relations among the elderly, the experts shall consider sleep and its quality as one of the explanatory factors of cognitive function. It is suggested to adopt plans managing sleep disorders and decreasing inappropriate use of sleeping medications.

Conflict of Interests

Authors have no conflict of interests.

Acknowledgments

We appreciate all the people who helped us in conducting this research, especially the head of the retirees association in Mashhad. This article is based on the MA thesis of Elham Montazar at the Department of Psychology, School of Literature and Human Sciences approved by University of Guilan, Rasht, Iran (registered thesis number: 2-51867). The authors confirm that they do not have any financial dependency to any organizations, and they have discussed the article topic eagerly.

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