ORIGINAL ARTICLE

Evaluation of Sleep Disorders in the Elderly with Vestibular Vertigo

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Abstract

Background: Vestibular vertigo and decreased sleep quality are prevalent issues that significantly affect the life expectancy, quality of life, and mental health of the elderly. Evidence from human and animal studies suggests a link between sleep disorders and vertigo. However, this association has not been sufficiently explored in the elderly population. The present study investigates the associations between vertigo-induced handicap and sleep quality in older people.
Methods: This cross-sectional study included individuals aged 60–70 with vestibular vertigo. The participants completed two questionnaires—the Dizziness Handicap Inventory (DHI) and the Pittsburgh Sleep Quality Index (PSQI)—in the presence of one of the authors.
Results: In this study, 96% of participants exhibited some degree of poor sleep quality. Correlation analysis revealed positive relationships between PSQI subcategory scores and specific domains of the DHI. Subjective sleep quality was significantly associated with DHI-Total (DHI-T), DHI-Emotional (DHI-E), and DHI-Functional (DHI-F) scores. Sleep disturbance showed significant links with the DHI-E and DHI-F domains. The use of sleeping medication was significantly correlated with DHI-T, DHI-E, and DHI-F scores, while daytime dysfunction was associated with DHI-T and DHI-F scores ($P<0.05$). However, the PSQI-Total (PSQI-T) score did not show significant correlations with DHI-T, DHI-P (Physical), DHI-E, or DHI-F scores ($P>0.05$).
Conclusion: This study demonstrated that, in elderly individuals with vestibular vertigo, there is a correlation between the degree of vertigo-induced handicap and various dimensions of sleep quality. Specifically, as the handicap worsens, sleep quality deteriorates. These findings underscore the importance of assessing sleep quality when evaluating elderly patients with vestibular vertigo.

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Keywords: Elderly, Dizziness, Vertigo, Sleep quality, Diziness handicap inventory

Introduction

Due to increased life expectancy, reduced mortality, and declining birth rates, the elderly population is growing worldwide, including in Iran. This demographic shift has increased the demand for health services tailored to this population.[1] Aging is accompanied by inherent biological and pathological changes experienced by all organisms.[2] Dizziness is one of the most common symptoms in older adults, typically occurring during head movements or walking, significantly increasing the risk of falls.[3] According to one-year prevalence estimates, 20% of individuals over 60, 30% of those over 70, and 50% of those over 80 experience significant

dizziness that necessitates medical attention and restricts daily activities.[4] Progressive multimodal balance impairments, including the degeneration of vestibular and proprioceptive structures and functions, as well as disruptions in the central integration of these sensory inputs, contribute to dizziness and related complaints in the elderly. This condition is called presbystasis, presbyequilibrium, or multisensory dizziness.[5] Vestibular vertigo is a major and prevalent cause of dizziness and imbalance in older adults,[5] with significant impacts on morbidity, mortality, and healthcare resource utilization.[6]

Although sleep patterns may change throughout life, sleep disturbances are not a typical part of the aging process. Nevertheless, they are highly prevalent in old age, often accompanying chronic medical conditions. Insomnia, a common type of sleep disorder, has a prevalence of 10% to 50% in the elderly, which is significantly higher than in other age groups.[7] Age-related sleep changes and insomnia are characterized by difficulty falling asleep, waking up earlier, increased frequency of awakenings, nighttime awakenings, and a reduction in deep sleep duration.[8, 9] Insomnia has serious consequences, including depression, anxiety, an increased risk of vascular dementia and Alzheimer's disease, and a negative impact on the overall health of the elderly. Numerous risk factors, including vestibular vertigo, and the interactions between these factors are associated with the development and incidence of insomnia.[7]

Sleep disorders can affect the vestibular system. Sleep deprivation has been shown to alter the posterior parietal cortex, which plays a crucial role in processing vestibular information and representing the surrounding space.[9] Gomez et al. (2008) reported that 36 hours of sleep deprivation impairs healthy individuals' ability to control posture, as measured by posturography.[10] Similarly, Gallina (2010) assessed vestibular function in patients with obstructive sleep apnea syndrome (OSAS) and found a higher prevalence of caloric testing abnormalities, longer latency in saccadic eye movements, and alterations in smooth-pursuit movements.[11]

Due to the extensive connections between the vestibular system and various brain centers, including those that regulate sleep, vestibular disorders are considered a significant cause of vertigo and contribute to sleep disturbances. A study of adult patients revealed that individuals with bilateral vestibular disorders exhibit abnormal sleep patterns and shorter sleep durations than healthy individuals.[12] Research has also established neural connections between the vestibular system, sleep regulation, and circadian rhythm centers.[13] As demonstrated in rodents, the vestibular nucleus is linked with the suprachiasmatic nucleus (SCN) via the lateral intergeniculate region. The SCN is the center for regulating the body's biological rhythm and altering sleep and wakefulness, whose processes are modulated directly and indirectly by environmental factors such as light and vestibular information.[14, 15]

Valid instruments, such as the Dizziness Handicap Inventory (DHI) and the Pittsburgh Sleep Quality Index (PSQI), have been utilized to investigate the connections between sleep disorders and various causes of vertigo, including vestibular disorders, psychological issues, post-traumatic brain injury, and presbystasis. Findings have demonstrated a significant correlation between dizziness handicaps and the severity of sleep disorders.[16, 17] Furthermore, sleep disturbances in patients with chronic vertigo are often accompanied by anxiety and severe depression.[16]

Helbig et al. (2013) explored the association between sleep disorders and the risk of falls in the elderly, considering the effects of age and dizziness. They identified a positive correlation between sleep disorders and an increased risk of falls in individuals over 75, including those without dizziness.[9]

The literature review revealed limited research studies examining the association between sleep problems and vestibular disorders in the elderly. While the connection between vestibular vertigo and sleep disturbances has been partially established, it has yet to be thoroughly explored in older adults. Vestibular vertigo and sleep problems are common complaints in the elderly, contributing to increased stress, depression, and a decline in quality of life in this population. Therefore, it is essential to investigate the relationship between these two factors in older people. This study aimed to evaluate and analyze sleep problems in elderly individuals with vestibular vertigo.

Methods

1. Participants

Fifty individuals of both genders, aged 60 to 70 years, with vestibular vertigo, were enrolled in this prospective study. The participants were elderly individuals who sought consultation from otolaryngology specialists at a daily center for the elderly in Hamedan due to balance problems and dizziness. They were selected using a convenience sampling method. The participants were initially interviewed using a standard vestibular vertigo diagnosis flowchart, referenced from the 2008 National Health Interview Survey (NHIS) in Albathi and Agrawal's article.[18] The diagnosis of vertigo was based on the flowchart and the diagnosis provided by an otorhinolaryngologist. The NHIS flowchart questions are listed in Table 1.

An otorhinolaryngologist diagnosed the causes of vertigo based on the elderly participants' examination and medical records. Among the participants, 17 had Benign Paroxysmal Positional Vertigo (BPPV), 16 had unilateral or bilateral reduced vestibular response, 6

Table 1: Vestibular vertigo case definition

1	• Do you have an imbalance or vertigo over the last 12 months? The patients who answered negatively to the question were excluded from the study; the participants who answered "yes" were asked the following questions.
2	• Have you experienced blurred vision while turning your head, as well as nausea and vomiting? Have you experienced imbalance and unsteadiness, causing difficulty standing and walking, as well as nausea and vomiting? (a positive answer to one of these questions would indicate the presence of vestibular vertigo. In case of a negative answer, the next questions were asked).
3	• Over the past 12 months, have you suffered from dizziness episodes and disequilibrium, vertigo, and a feeling of spinning? (a positive answer to this question indicates the presence of vestibular vertigo).
4	• Do you experience dizziness and imbalance when you turn your head to the sides? Do you experience these conditions when you look up and down? a positive answer to one of these questions would indicate the presence of vestibular vertigo.

Table 2: Mean and standard deviation of Dizziness Handicap Inventory and Pittsburgh Sleep Quality Index scores

Questionnaires	Number	Mean (±SD)
Dizziness Handicap Inventory -Total	50	51.14 (±26)
Dizziness Handicap Inventory -P	50	14.8 (±6.7)
Dizziness Handicap Inventory -E	50	14.6 (±12.11)
Dizziness Handicap Inventory -F	50	21.7 (±10.37)
Pittsburgh Sleep Quality Index -Total	50	13.16 (±4.72)
Subjective sleep quality	50	1.84 (±1.03)
Sleep latency	50	2.26 (±0.89)
Sleep duration	50	2.4 (±0.9)
Habitual sleep efficiency	50	1.84 (±1.29)
Sleep disturbances	50	1.78 (±0.76)
Use of sleeping medication	50	1.58 (±1.47)
Daytime dysfunction	50	1.62 (±1.15)

Table 3: Correlation coefficients between Dizziness Handicap Inventory and Pittsburgh Sleep Quality Index scores

Variables	Dizziness Handicap Inventory -Total	Dizziness Handicap Inventory -P	Dizziness Handicap Inventory -E	Dizziness Handicap Inventory -F
Pittsburgh Sleep Quality Index -Total	0.26	0.23	0.25	0.31
Subjective sleep quality	0.32*	0.23	0.38**	0.3*
Sleep latency	-.2	-0.03	-0.19	-0.09
Sleep duration	-0.06	-0.036	-0.1	-0.13
Habitual sleep efficiency	0.005	0.14	-0.02	-0.03
Sleep disturbances	0.23	0.16	0.28*	0.33*
Use of sleeping medication	0.4**	0.107	0.33*	0.5**
Daytime dysfunction	0.4**	0.25	0.5**	0.3*

*Correlation is significant at the 0.05 level (two-tailed). **Correlation is significant at the 0.01 level (two-tailed).

had delayed endolymphatic hydrops, 3 had trauma, 3 had sudden deafness with vertigo, 3 had vestibular neuronitis, and 2 had labyrinthitis. All participants were in a non-acute (non-attack) condition.

The inclusion criteria were: age above 60 years; presence of vestibular vertigo as per the NHIS definition of vestibular vertigo;[19] absence of cognitive disorders, with a score above 25 on the Mini-Mental State Examination (MMSE);[20] signing consent forms for participation; and absence of severe vascular and respiratory problems, neck problems, orthopedic or wheelchair dependence,[17, 18] as well as conditions such as stroke, movement disorders, multiple sclerosis, spinal cord injuries, muscular dystrophy, muscle degeneration, glaucoma, diabetic retinopathy, and cataracts.[18]

This study was conducted over 8 months. The study protocol was approved by the ethics committee of Hamadan University of Medical Sciences (ethics code: IR.UMSHA.REC.1400.888).

2. Evaluations

The Dizziness Handicap Inventory (DHI) and Pittsburgh Sleep Quality Index (PSQI) were administered to the eligible participants. The instruments and their scoring systems are described below.

2.1. Persian Version of the Dizziness Handicap Inventory (DHI)

The Persian version of the DHI contains 25 items that assess the consequences of vestibular and balance disorders. The overall score ranges from 0 (no disability) to 100 (severe disability) and includes three domains: physical (DHI-P), emotional (DHI-E), and functional (DHI-F). In the original version of the questionnaire, a cut-off point of 14 is considered the normal/abnormal criterion. In the Persian version, a cut-off point of 10, with 100% sensitivity and specificity, distinguishes between non-disabled individuals and those with vertigo.[21, 22]

2.2. Persian Version of the Adult Pittsburgh Sleep Quality Index (PSQI)

The Persian version of the PSQI is a self-assessment tool used to evaluate sleep disorders and quality over the previous month. The PSQI consists of 18 questions, each scored from 0 to 3 on a 4-point Likert scale. This questionnaire assesses various

factors, including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. A score of 5 or higher on the questionnaire indicates poor sleep quality.[23] Boyce et al. (1989), who originally developed this questionnaire, determined its internal consistency using Cronbach's alpha, which yielded a value of 0.83. The Cronbach's alpha coefficient for the Persian version of this questionnaire was 0.78.[24]

3. Statistical Analysis

Statistical analyses were performed using SPSS version 23 (IBM, Armonk, NY, USA). Descriptive statistics were used to summarize the data, including mean (standard deviation) and number (percentage). The Kolmogorov-Smirnov test was employed to assess the normality of the data distribution, and the Spearman correlation coefficient was used to evaluate correlations. A significance level of $P<0.05$ was considered statistically significant.

Results

This study was conducted with 50 older adults suffering from vestibular vertigo, with an average age of 68.26±8.9 years. Among these participants, 24 (48%) were women and 26 (52%) were men.

The mean scores of the Dizziness Handicap Inventory (DHI), the Pittsburgh Sleep Quality Index (PSQI), and their subcategories are presented in Table 2. In the PSQI, 48 (96%) participants scored above 5, 2 (4%) scored precisely 5, and 38 (76%) scored above 9, indicating a definite sleep disorder.[4]

The results of the correlation between the scores of the DHI and PSQI questionnaires are detailed in Table 3. According to these results, there was a significant positive relationship between the scores of the PSQI subcategories and the DHI total and domain scores, as described below:

Subjective sleep quality correlated significantly with the DHI-Total (rho=0.32, P=0.024), DHI-E (rho=0.40, P=0.006), and DHI-F scores (rho=0.30, P=0.032). A significant correlation was found between the sleep disturbance subcategory and the DHI-E scores (rho=0.28, P=0.05) and DHI-F scores (rho=0.33, P=0.02). The associations between the use of sleep medication and the DHI-Total (rho=0.40, P=0.006), DHI-E (rho=0.33, P=0.02), and DHI-F (rho=0.50, P<0.001) were significant, as were the relationships between daytime dysfunction and the DHI-Total (rho=0.40, P=0.004), DHI-E (rho=0.50, P<0.001), and DHI-F scores (rho=0.30, P=0.04). Finally, the PSQI-Total exhibited no significant positive correlation with the DHI-Total, DHI-P, DHI-E, or DHI-F scores (P>0.05).

Discussion

The primary goal of this study was to examine sleep quality in the elderly population with vestibular vertigo complaints and to explore the relationship between sleep quality (across all subcategories of the PSQI) and vertigo-induced handicap. Previous studies have typically included a wide age range and did not specifically focus on the elderly group, nor have they investigated all the components of sleep disorders. According to the findings of this study, 96% of participants exhibited poor sleep quality.

Helbig et al. (2013) investigated the association between falls and various sleep disturbances in older people while considering age and dizziness. Their findings revealed a strong correlation between longer sleep patterns, difficulty falling asleep, trouble staying asleep, and falls in older people.[9] Monirah Albathi and Yuri Agrawal (2017) explored the relationship between vestibular vertigo and sleep duration in 20,950 American adults. They demonstrated that individuals with vestibular vertigo were more likely to experience sleep problems than those without vertigo, with their sleep duration either abnormally short or long.[18]

What distinguishes the present study from Albathi and Agrawal's is that our study specifically focuses on the elderly population and investigates various aspects of sleep disorders and their relationship with vertigo-induced handicaps in this age group.

Previous research has shown that patients aged 31 to 71 years with Meniere's disease spend less time in deep sleep than healthy individuals, while their level of arousal is higher.[25, 26] In a study involving 52 adults over the age of 57 who had complaints of vestibular vertigo and other conditions (including those of psychotic or autonomic origin), Konomi (2014) found that the PSQI score was higher in groups with psychotic dizziness and autonomic imbalance.[17] The results of this study confirmed a high rate of sleep disturbance in patients with vertigo, indicating that sleep quality affects various types of dizziness and vertigo.[17]

The present study found no significant correlation between the PSQI and DHI total scores. However, the subjective sleep quality, use of sleeping medication, and daytime dysfunction in the PSQI were found to correlate significantly with the total score and the emotional and functional domains of the DHI. Similarly, significant associations were observed between sleep disturbance and the emotional and functional domains of the DHI. There is insufficient evidence to draw firm conclusions about the relationship between vestibular vertigo and sleep disorders in the elderly. Nevertheless, studies across various age groups and clinical populations have identified a link between dizziness and poor

sleep quality.[26-28] Kim (2018) discovered a positive correlation between the PSQI and total DHI scores in adults with vestibular vertigo (vestibular migraine and BPPV) of psychological origin. This study, however, did not examine the relationship between the PSQI subcategories and the DHI. Iranfar and Azad (2022) found that adults (mean age 51) with BPPV exhibited poorer sleep quality than the control group concerning four components of the PSQI (subjective sleep quality, use of sleep medications, daytime dysfunction, and sleep disturbance).[28] Relatively similar results have been reported in other studies on older people and adult populations with BPPV.[27] PPV is a common cause of dizziness, especially in the elderly, accounting for approximately one-third of vertigo cases.[29] Studies suggest poor sleep quality may contribute to the recurrence of vertigo attacks.[28]

Multiple mechanisms may explain the relationship between vestibular vertigo and sleep disturbances. The vestibular system, which senses the head's position relative to the earth's gravity, may provide critical signals for the onset and maintenance of sleep.[18] Vestibular sensory inputs, particularly those from otolithic receptors, immediately affect the suprachiasmatic nuclei (SCN). The SCN controls the circadian rhythm and regulates many of the body's functions in a 24-hour cycle through its hormonal and neurological activities. As demonstrated in rodents, the vestibular nucleus is connected to the SCN via the lateral intergeniculate region. Animal studies indicate that the vestibular system and the visual and somatosensory systems play a role in regulating circadian rhythms.[13] Various synchronizing social and environmental inputs, such as light, influence SCN neurons. Vestibular inputs, particularly those from otolithic organs, also synchronize biological rhythms.[13, 18, 30] According to physiological evidence, labyrinthine inputs affect neurons in the reticular formation, which modulates sleep patterns. Furthermore, the middle vestibular nucleus receives orexinergic inputs from the lateral hypothalamus, influencing areas mediating arousal and specific sleep aspects.[31]

Research into the relationship between sleep disorders and vestibular vertigo is still emerging and yet to be well-established. However, numerous researchers have suggested a link between sleep and the vestibular system. Several studies indicate that sleep disturbances affect the cortical processing of vestibular signals.[19] In a study conducted by Lin and Young, sleep deprivation was found to increase the asymmetry of the ocular vestibular-evoked myogenic potential (oVEMP) response and the vestibular-ocular reflex (VOR) gain.[32] Additionally, there are theories regarding the impact of the vestibular system on sleep and circadian rhythm centers. Evidence supports this theory, showing that the vestibular system has major connections to the centers regulating different sleep stages. Vestibular inputs to the autonomic nervous system enable the vestibular system to regulate autonomic functions during rapid eye movement (REM) sleep.[32]

The neural plasticity of cognitive and sensory systems is influenced by slow-wave sleep, paradoxical sleep, and theta waves during REM sleep. Evidence has shown that sleep also impacts vestibular information related to learning and neuroplasticity. The plasticity of the vestibular cortex, hippocampus, visual cortex, cerebellum, and vestibular nuclei is modulated by sleep during vestibular compensation.[13] Sleep disturbances and poor sleep quality could hinder vestibular recovery and compensation. Due to the slow nature of the compensation process, the adverse effects of sleep disorders on neuroplasticity are more pronounced in the elderly population,[33] emphasizing the need to assess sleep disorders in older adults with vestibular vertigo.

Patients with vestibular vertigo frequently report sleep disturbances. Sleep problems associated with dizziness in older people appear to have more severe consequences than in other age groups. Therefore, studying sleep disorders is crucial for predicting the effects of vestibular vertigo and developing the necessary diagnostic and therapeutic strategies.

A limitation of this study was the lack of a comprehensive evaluation of the elderly participants' mental, psychological, and social conditions. Since psychiatric disorders, such as depression and anxiety, are closely linked to sleep disturbances,[34] and the prevalence of mental health issues is higher in the elderly,[35] it is recommended that future studies account for these potential confounding factors. Additionally, in this study, the patients' scores were compared against the cut-off points of the questionnaires without including a control group. It is suggested that future studies involve a larger sample size and incorporate a control group to strengthen the findings.

Conclusion

This study found that some older adults with vestibular vertigo experience poor sleep quality, and there is a significant correlation between vertigo-induced disability and various dimensions of sleep quality. In clinical settings, it may be beneficial to prioritize the diagnosis of sleep disorders in elderly patients with vestibular vertigo. In addition to routine measures for evaluating the causes of dizziness and vertigo, it is crucial to consider other aspects, including sleep issues, which can significantly impact the quality of life in this population. Furthermore, investigating the effect of vestibular rehabilitation on sleep quality would provide valuable insights into the interaction between sleep and vertigo, enhancing our understanding of their relationship.

Highlights:

- High rate of sleep disturbances in elderly individuals with vestibular vertigo.
- Significant relationship between certain aspects of sleep quality and dizziness-induced handicap in older people.
- The importance of diagnosing sleep disorders in elderly patients with vestibular vertigo.

Plain Language Summary:

Vestibular and sleep disorders are common complaints in the elderly population, significantly affecting their quality of life and overall health prognosis. Investigating the relationship between these two disorders is crucial for understanding their underlying causes and developing effective intervention strategies. In this study, a group of elderly individuals with vestibular vertigo was assessed to evaluate dizziness-induced handicap and sleep quality. The findings revealed that a significant proportion of participants had poor sleep quality. Additionally, a positive relationship was observed between some subcategories of the sleep quality questionnaire and the scores of the dizziness handicap inventory. This indicates that as sleep quality declines, the handicap caused by dizziness worsens, and vice versa. The results of this study highlight the importance of assessing sleep status in elderly patients with vestibular vertigo, which should be included in the routine evaluation and management of this population.

Authors' Contribution

Conceptualization: Zahra Hosseini Dastgerdi, Nasrin Gohari. Data curation: Zahra Hosseini Dastgerdi, Nasrin Gohari. Formal analysis: Nasrin Gohari, Mobina Mehrabifard. Investigation: Zahra Hosseini Dastgerdi, Nasrin Gohari, Mobina Mehrabifard. Methodology: Zahra Hosseini Dastgerdi, Nasrin Gohari. Project administration: Zahra Hosseini Dastgerdi, Nasrin Gohari, Mobina Mehrabifard. Resources: Zahra Hosseini Dastgerdi, Nasrin Gohari. Software: Hasti Seifi, Bahare Khavarghazalani. Supervision: Zahra Hosseini Dastgerdi, Nasrin Gohari. Validation: Mobina Mehrabifard, Hasti Seifi. Visualization: Zahra Hosseini Dastgerdi, Nasrin Gohari. Writing—original draft: Zahra Hosseini Dastgerdi, Nasrin Gohari. Writing—review & editing: Hasti Seifi, Bahare Khavarghazalani. Approval of final manuscript: all authors.

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