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# The relationship between sleep quality and dynamic balance in the elderly

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## ABSTRACT

**Background:** The aging process in older adults will bring comprehensive changes related to the ability of their physiological functions. This condition causes the elderly's sleep patterns to change with various sleep disorders, resulting in poor sleep quality. The decrease in sleep quality in the elderly can affect their quality of life, including balance disorders. This study aimed to determine the relationship between sleep quality and dynamic balance in the elderly.
**Methods:** This research used a cross-sectional study conducted in Nyuh Kuning Traditional Village, Mas, Ubud, Gianyar, in November 2023. The sampling technique used in this study was total sampling with a sample size of 43 people aged 60 years and over. Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI) questionnaire, and dynamic balance was calculated using the Time Up and Go Test (TUG Test).
**Results:** The research subjects were dominated by the elderly with poor sleep quality, 30 of whom were elderly (69.8%). Meanwhile, in dynamic balance, most research subjects had variations in dynamic balance and mobility, and the result of the TUG Test (+) was 33 elderly (76.7%). The obtained Sig. (2-tailed) value of the correlation between sleep quality and dynamic balance was 0.000 (<0.05). Sleep quality strongly correlates with dynamic balance, with a correlation coefficient (*r*) of 0.836, indicating a positive relationship.
**Conclusion:** There was a positive significant relationship between sleep quality and dynamic balance in the elderly.

**Keywords:** dynamic balance, elderly, Pittsburgh sleep quality index, sleep quality, time up and go test.
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## INTRODUCTION

Elderly or elderly is someone who enters the age of more than 60 years.[1,2] The elderly is a stage of human life that experiences a slow decline in the ability of various organs and body systems physiologically.[3] This is because the ability to maintain the structure of cells or tissues and their typical functions also slowly disappears, making it difficult to survive when conditions of infection and damage occur. This condition is called aging. This aging process causes complex changes in physical, psychological, and social conditions related to each other. This condition has the potential to cause various health problems in the elderly.[4]

This physiological decline includes the habits and quality of sleep of the elderly. Sleep is a state of decreased awareness and response of the body to the environment. A person can be reawakened during sleep with sufficient stimulation.[5] Sleep is a physiological necessity that happens naturally in humans and can cause changes in consciousness status, characterized by decreased consciousness and responsiveness to the stimulus.[6] Sleep can reduce fatigue, stabilize mood, increase blood flow to the brain, enhance protein synthesis, maintain the immune system's disease-fighting mechanisms, promote cell growth and repair, and improve learning capacity and memory storage.[7] Sleep quality measures how easy it is for a person to initiate sleep and maintain sleep. Good sleep quality can be seen when a person wakes up feeling refreshed and energized to carry out activities.[8]

Sleep disturbances are more familiar with age. Over 80% of seniors aged 65 years and above report experiencing sleep disturbances.[9] Sleep disturbances in the elderly can be characterized by shortened sleep duration and increased frequency of night waking. Sleep problems often experienced by the elderly include frequent night wakings, early morning awakenings, difficulty falling asleep, and excessive fatigue during the day.[10] In the group of 60-year-old individuals, 7% complained of experiencing poor sleep quality, with a maximum of only five hours of sleep a day. In the group of 70-year-old individuals, similar cases occurred in 22%.[11] The prevalence rate of poor sleep quality among the elderly is relatively high, at around 67%. Poor sleep quality can be a risk factor for body instability that affects balance and gait in the elderly.[12] In a study by Weber et al. in 2013 regarding sleep credit/banking sleep, the quality of a person's sleep correlates with the volume of grey matter in the brain.[13] Gray matter volume will impact balance in the left rectus/superior and frontal medial orbital gyrus.[14] In addition, there is an increase in body sway due to the difficulty of sensory integration (visual, somatosensory, and vestibular) due to poor sleep quality (sensory system, incredibly visual) in obtaining information to be sent to the

central nervous system and sending output for motor activity in controlling balance to be unstable.[12]

Balance is obtained when the center of mass of the body (center of mass) or center of gravity (center of gravity) is controlled against the fulcrum (base of support).[15] Dynamic balance is a person's ability to maintain the equilibrium of his body in various positions, such as walking, running, and moving.[16] Balance is formed from the cooperation of specific components in several body systems that are interconnected and continuous. These components include visual components, vestibular components, somatosensory (proprioceptive) components in the nervous system, and strength and flexibility components in the musculoskeletal system.[17]

The prevalence of elderly balance disorders in Indonesia is 63.8% - 68.7%, according to the Ministry of Health of the Republic of Indonesia in 2012. Meanwhile, the elderly in Bali Province regarding their body balance disorders are assumed to be 30-50%.[18] Balance disorders in the elderly make them prone to tripping and slipping, causing them to fall. A third of people in the community over 65 fall every year, and about 20% to 25% of them will fall repeatedly. Falls can result in a variety of injuries, not only physical damage but also psychological impact.[11] This study aimed to determine the relationship between sleep quality and dynamic balance in the elderly. The researcher hypothesized that poor sleep quality in older adults will reduce their dynamic balance.

## METHODS

This research design used a quantitative observational analytic with a sectional approach. This research was conducted in Nyuh Kuning Traditional Village, Mas, Ubud, Gianyar, on November 5, 2023. The independent variable in this study was sleep quality, and the dependent variable was dynamic balance. The control variables in this study were age, physical activity, and BMI.

The sample inclusion criteria in this study were elderly aged ≥ 60 years, with average vital sign measurement values, able to communicate verbally (understand instructions and respond well), have moderate physical activity, have regular and overweight BMI, and willing to follow the research process by agreeing to informed consent. This study's exclusion criteria were samples with musculoskeletal problems, neurological disorders, visual and hearing impairments, psychological disorders, and using walkers.[19]

The sample was obtained from 43 older adults using a total sampling technique. This study has two data analyses, namely univariate analysis and bivariate analysis. Univariate analysis will describe the distribution of characteristics of age, gender, sleep quality, dynamic balance, BMI, and physical activity. In contrast, bivariate analysis uses the *Spearman-Rho* correlation test to determine the relationship between sleep quality and dynamic balance in the elderly. The Research Ethics Commission of the Faculty of Medicine, Universitas Udayana/Sanglah Hospital Denpasar, with the number 2264/UN14.2.2.VII.14/LT/2023 accepted this study based on its ethical feasibility. Each person in this study gave informed consent and agreed to participate.

## RESULTS

From a total of 43 research samples, the characteristics of the research samples obtained in this study include age, gender, BMI, physical activity, sleep quality, and dynamic balance. After univariate analysis, frequency distribution data and percentages of research sample characteristics were found, which can be seen in Table 1.

Table 1 shows that based on age, the entire sample is ≥60 years old because it includes as many as 43 older adults (100%) in this study. Based on gender, it can be seen that it is also dominated by female research samples, namely 36 elderly (83.7%) while men are seven elderly (16.3%). Based on the BMI of normal BMI elderly, there are as many as 19 elderly (44.2%), while the elderly are overweight, and there are as many as 24 elderly (55.8%). All older adults who became research samples had a moderate level of physical activity, namely 43 older adults (100.0%). Sample characteristics with normal BMI and overweight and moderate physical activity levels are the inclusion requirements for sample selection in this study. Based on the level of sleep quality, most of the samples had poor sleep quality. As many as 30 elderly (69.8%) and only 13 elderly (30.2%) had good sleep quality. Information on the level of dynamic balance shows that the majority of elderly with TUG (+) results are as many as 33 elderly (76.7%), while the elderly with TUG (-) results are ten elderly (23.3%).

Table 2 shows the results of the Spearman rho correlation test between the sleep quality variable and dynamic balance in the elderly, showing a significant relationship with the Sig value. (2-tailed) of 0.000, which is smaller than 0.05. The correlation coefficient (r) obtained is 0.836, which means the correlation is robust because the value is between 0.700 and 0.890. Meanwhile, the positive value in the correlation coefficient indicates a unidirectional relationship. The unidirectional relationship means that the better the quality of sleep, the better the level of dynamic balance in the elderly in Nyuh Kuning Traditional Village, Mas, Ubud, Gianyar.

## DISCUSSION

Sleep in the human routine is no less important than eating and drinking. Human time is spent more awake than asleep, so the brain works more often than it rests. The glymphatic system cleans neurological waste in the central nervous system when asleep. When nerve cells deliver stimuli, a protein called amyloid-beta protein accumulates in the brain daily and is considered neurological waste. This protein will increase in number while awake. The brain will work to clear the protein during sleep, especially in the deep sleep or slow wave phase. The accumulation of amyloid-beta protein will form plaques and damage nerve cells.[20]

Age dramatically affects the quality of sleep, where the higher the person's age, the lower the duration of sleep.[10] Sleep patterns also undergo typical changes when entering old age. Changes in the neurological system decrease the number and size of neurons in the central nervous system, which results in reduced neurotransmitter function. A decreased distribution of serotonin follows this as a sleep-inducing hormone. In the sleep

**Table 1. Frequency distribution of sample characteristics**

| Variable Characteristics | Frequency (n) | Percentage (%) |
|---|---|---|
| Age | | |
| ≥60 years | 43 | 100.0 |
| Gender | | |
| Men | 7 | 16.3 |
| Women | 36 | 83.7 |
| BMI | | |
| Normal | 19 | 44.2 |
| Overweight | 24 | 55.8 |
| Physical Activity (IPAQ) | | |
| Moderate Physical Activity | 43 | 100.0 |
| Sleep Quality (PSQI) | | |
| Good | 13 | 30.2 |
| Bad | 30 | 69.8 |
| Dynamic Balance (TUG) | | |
| TUG (-) | 10 | 23.3 |
| TUG (+) | 33 | 76.7 |

**Table 2. Spearman Rho Correlation test results between the relationship between sleep quality and dynamic balance in the elderly**

| Relationship between sleep quality and dynamic balance | |
|---|---|
| *Correlation Coefficient* | 0.836 |
| *Sig. (2-tailed)* | 0.000 |
| N | 43 |

patterns of the elderly aged >60, the percentage of sleep stages 3 and 4 in the NREM phase decreased linearly by 2% per decade, followed by a slow decline in the REM phase. The elderly tend to choose to start sleeping at night and wake up too early because of the influence of the circadian sleep cycle (24-hour cycle with control centers in the ventral anterior hypothalamus).[2,12] This phenomenon occurs because the deterioration of the body's functions during aging disrupts the synthesis of the hormone melatonin. The circadian rhythm that regulates the body's wake-up time highly depends on this hormone. Wakefulness is inhibited through the reaction between melatonin and the Suprachiasmatic Nuclei (SCN).[21] This leads to a reduced need for sleep when entering old age.[22]

When sleep quality decreases, physiological changes occur in the body. During sleep, the body produces cytokine proteins that maintain the immune system and are needed to fight infection and inflammation. When the quality of sleep decreases, the ability of white blood cells and lymphocytes weakens. Sleep quality also affects the mechanism of cell growth and repair. During sleep, growth hormone (GH) will be produced in the slow wave sleep phase (NREM III and IV) stimulated by Growth Hormone Releasing Hormone (GHRH). Slowing down the body's work during sleep can provide an opportunity for healing cells to repair damaged cells through growth hormones. This is what makes older adults with poor sleep quality vulnerable to various diseases.[23]

Sleep quality correlates with grey matter volume in the brain. Grey matter volume will impact balance in the left rectus/superior and frontal medial orbital gyrus. The greater the volume of grey matter affected, the poorer the sleep quality. The cerebellum, which processes coordination and regulation of posture, movement, and balance, and the brainstem, which integrates sensory information, will be affected by this grey matter volume.[14] Decreased sleep quality can reduce the ability of the elderly to control their balance and increase the risk of sarcopenia and muscle weakness.[24] Sleep disturbances such as decreased duration favor proteolysis, resulting in altered body composition and increased risk of insulin resistance, which is associated with sarcopenia.[25]

Sleepiness due to inadequate sleep indicates increased melatonin levels in the blood. Melatonin interacts explicitly with the cerebrovestibular control part of the vestibular reflex. This interaction will stimulate increased inhibition of oculomotor movements and vestibulospinal reflexes in the cerebellar system. This inhibition in the cerebellar system is through the ARAS and ARIS systems. The ARAS and ARIS systems are located in the brainstem's reticular formation. This system also influences eye movements and vestibular nuclei for attitude control.[14] The changes due to decreased sleep quality impact the elderly, who tend to feel weak, dizzy, tired, difficult to focus, and easily stressed.[26] In addition, the impact that can be caused by poor sleep quality in the elderly can be decreased endurance, cognitive decline, slow healing process, poor neuromuscular coordination, and vital sign instability due to autonomic nervous imbalance.[27]

The brain regulates balance by interacting with the somatosensory system (visual, vestibular, and proprioceptive) with the motor system (bones, muscles, joints, and other soft tissues).[28] Information received by sensory receptors will be forwarded to the cerebral cortex (primary motor, premotor, and supplementary motor cortex) for processing and producing motor signals. When there is a sensory signal, the body forwards the signal through mechanoreceptors to be submitted to the postcentral gyrus of the cerebral cortex. Furthermore, the information is processed into pyramidal fibers until it reaches the anterior motor neurons. Anterior motor neurons forward this action potential to the terminal axon, giving rise to an end plate potential that will spread along the muscle membrane. This is the mechanism of contraction in antigravity muscles. The body will provide corrective or protective movements as feedback to a sudden force or a changing fulcrum.[29]

A decrease in sleep quality will affect the ability to maintain these interactions. Poor sleep quality is related to disrupting visual, vestibular, and somatosensory input processes and their integration into the central nervous system to produce motor output. This causes movement coordination to be less smooth and

purposeful and increases body sway in the elderly.[2] Sleep quality will also affect the focus and clarity of the visual system (noise postural control system). When an external force hits the body or a sudden internal force, the body will quickly and precisely respond to the force through the integration process of the nervous system that affects balance.[22] Poor sleep quality also leads to reduced concentrations of the neurotransmitter serotonin, leading to reduced concentration and slowed reaction time to adapt postures to keep the body in balance.[30] This makes the dynamic balance of the elderly decrease, causing them to trip and fall easily.[24]

Similar research results were also obtained in the research of Serrano-Checa et al. (2020), which showed that most older women with poor sleep quality experienced a decrease in walking speed dynamic imbalance and required more time to complete functional mobility tests. The relationship between sleep quality and dynamic balance may be explained by the fact that restorative sleep is necessary for learning, acquiring, and maintaining motor abilities. Hence, people who experience non-restorative sleep have difficulty learning new motor skills and even show a tendency towards decreased performance. This trend was observed to be stronger among the elderly. In addition, non-restorative sleep has been shown to impair motor control, leading to increased coordination difficulties, thus affecting the ability to walk and turn smoothly.[31]

esearchers faced some difficulties when conducting this research; the study was unable to adjust for other variables. For example, biomechanical characteristics such as posture shape can influence dynamic balance measurements in the elderly. In this study, researchers did not measure the elderly's posture, such as the degree of curvature of the body, which influences the location of the COG on the body in relation to the BOS. This parameter is expected to be included in future studies aimed at controlling the elderly's posture.

## CONCLUSION

There was a strong positive significant relationship between sleep quality and dynamic balance in the elderly in the Nyuh Kuning Traditional Village, Mas, Ubud, Gianyar.

## ETHICAL CLEARANCE

The Research Ethics Commission, College of Medicine, Universitas Udayana, has determined that this research is ethically feasible (number 2264/UN14.2.2.VII.14/LT/2023). Informed consent from survey respondents was also obtained, which approved the use of sampling.

## CONFLICT OF INTEREST

This study contains no conflicts of interest.

## FUNDING

This study got no funding from any institution.

## AUTHOR CONTRIBUTIONS

PAM prepares study designs, collects data, processes data, and writes manuscripts. SAPT, NKAJA, and GV are directing data collection and revising the manuscript.

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