T.C.

YEDITEPE UNIVERSITY

INSTITUE OF HEALTH SCIENCES

DEPARTMENT OF PHYSIOTHERAPY AND REHABILITATION

EFFECTS OF SLEEP QUALITY AND DAYTIME SLEEPINESS ON POSTURAL CONTROL IN HEALTHY YOUNG ADULTS

MASTER THESIS

İLKAY TUĞÇE KÖSE, PT, BSc

Istanbul-2022

T.C.

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

DEPARTMENT OF PHYSIOTHERAPY AND REHABILITATION

EFFECTS OF SLEEP QUALITY AND DAYTIME SLEEPINESS ON POSTURAL CONTROL IN HEALTHY YOUNG ADULTS

MASTER THESIS

İLKAY TUĞÇE KÖSE, PT, BSc

ADVISOR

Çiğdem YAZICI MUTLU, PT, PhD

İstanbul-2022

THESIS APPROVAL FORM

Institute : Yeditepe University Institute of Health Sciences

Programme : Master's Program in Physiotherapy and Rehabilitation

Title of the Thesis : Effects of Sleep Quality and Daytime Sleepiness on Postural Control in Healthy Young Adults

Owner of the Thesis : İlkay Tuğçe KÖSE

Examination Date : 07.02.2022

This study have approved as a Master Thesis in regard to content and quality by the Jury.

	Title, Name-Surname (Institution)
Chair of the Jury:	Asst. Prof. Elif DEVELİ Yeditepe University
Supervisor:	Asst. Prof. Çiğdem YAZICI MUTLU Yeditepe University
Member/Examiner:	Asst. Prof. Gönül ERTUNÇ GÜLÇELİK Istanbul Gedik University

APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated .... and numbered ....

Prof. Dr. Bayram YILMAZ

Director of Institute of Health Sciences

DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

07.02.2022

İlkay Tuğçe KÖSE

DEDICATION

To all the people I hold dear and near my heart, especially my mother and family.

Thank you for being in my life.

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my thesis advisor Asst. Prof. Çiğdem YAZICI MUTLU for her guidance and patience throughout my thesis process and graduate education.

I would also like to thank Professor Feryal SUBAŞI, for her support and guidance during my time as a student of Yeditepe University Physiotherapy and Rehabilitation Department, both in my undergraduate and graduate education.

I would like to thank both of them for everything they have done for me as an advisor, a teacher and a mentor.

I would also like to extend my appreciation to Asst. Prof. Gönül ERTUNÇ GÜLÇELİK for being patient with me and believing in me. I couldn't have asked for a better supervisor.

My sincere appreciation is also extended to my dear friends Sezgi AKBAŞ, İzel AVCI, Duygu KÖSEDAĞI and Sıla YILMAZ. I would like to thank them for being with me throughout this journey. Without them, I would be lost in many ways. I am grateful for their endless support, love, and friendship.

And my eternal gratitude goes to my family for their understanding, their love, and never-ending support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABREVIATIONS

º : Degree

º/sec: Degree per second

% : Percentage

AGP: Area Gap Percentage

AP: Anteroposterior

BMI: Body Mass Index

BOS: Base of Support

CCR: Cervico-collic Reflex

CG: Control Group

CM: Centimeter

COG: Center of Gravity

COM: Center of Mass

COP: Center of Pressure

EEG: Electroencephalogram

EG: Evaluation Group

EMG: Electromyography

EOG: Electrooculogram

ESS: Epworth Sleepiness Scale

GTO: Golgi Tendon Organ

KG: Kilogram

M: Meter

ML: Mediolateral

MS: Medium Speed

NREM: Non-rapid Eye Movement

N1: NREM stage 1

N2: NREM stage 2

N3: NREM stage 3

N4: REM sleep

PL: Perimeter Length

PSQI: Pittsburgh Sleep Quality Index

REM: Rapid Eye Movement

SCN: Suprachiasmatic Nucleus

SD: Standard Deviation

SPSS: Statistical Package for the Social Sciences

SSS: Stanford Sleepiness Scale

SWS: Slow-wave Sleep

VCR: Vestibulocollic Reflex

$\bar{X}$: Mean

X^2: Chi-Square Test

ABSTRACT

Köse, İ.T. (2022). Effects of sleep quality and daytime sleepiness on postural control in healthy young adults. Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, MSc Thesis, İstanbul.

The aim of this study is to investigate the effects of sleep quality and daytime sleepiness on postural control in healthy young adults. 62 healthy young adults (age: 22.60±3.63, F/M 39/23) between the ages of 18-35 were included in the study. After collecting demographic data from the volunteers participating in the study, they were asked to fill out the Pittsburgh Sleep Quality Index (PSQI) and Epworth Sleepiness Scale (ESS). According to the scores obtained from the scales, the participants were divided into two groups as the control group (PSQI≤5, ESS≤10) and the evaluation group (PSQI>5, ESS>10). Then, dynamic balance assessments of the participants were made via the Prokin PK200. Balance measurements were performed with eyes open in three different ways: bipedal, on the right foot, and on the left foot. At the end of the measurements, Perimeter Length, Area Gap Percentage, Medium Speed, Medium equilibrium center-AP, and Medium equilibrium center-ML data were obtained. Statistical analysis of the data was made using IBM SPSS Statistics Ver. 23, the results of the analysis were given as arithmetic mean, standard deviation, and frequency distribution, and Independent Groups T-test and Mann Whitney-U test were used in the analysis. Spearman Correlation Analysis was used for the correlation analysis between sleep quality and dynamic balance data. As a result of the statistical analysis, statistically significant differences were observed between the two groups in the values of the perimeter length assessed on the right foot, medium speed assessed on the right foot, and area gap percentage assessed on the left foot ($p<0.05$). When the correlation analysis was examined, there were positive weak correlations between PSQI and perimeter length assessed on the right foot ($r=.269$, $p=.034$), medium speed assessed on the right foot ($r=.273$, $p=.032$), and a negative weak correlation between PSQI and area gap percentage assessed on left foot ($r=-.255$, $p=.046$).

Key words: sleep quality, daytime sleepiness, postural control, PSQI, ESS

ÖZET (Turkish)

Köse, İ.T. (2022). Sağlıklı genç yetişkinlerde uyku kalitesi ve gündüz uykululuğunun postüral kontrol üzerine etkileri. Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Bölümü, Yüksek Lisans Tezi, İstanbul.

Bu çalışmanın amacı sağlıklı genç yetişkinlerde gece uyku kalitesi ve gündüz uykululuğunun postüral kontrol üzerine etkilerini araştırmaktır. Çalışmaya 18-35 yaş aralığında 62 sağlıklı genç yetişkin (yaş: 22,60±3,63, K/E 39/23) dahil edilmiştir. Çalışmaya katılan gönüllülerden demografik verileri toplandıktan sonra Pittsburgh Uyku Kalitesi İndeksi (PUKİ) ve Epworth Uykululuk Ölçeği (EUÖ)'ni doldurmaları istenmiştir. Ölçeklerden elde edilen puanlara göre katılımcılar kontrol grubu (PUKİ≤5, EUÖ≤10) ve ölçüm grubu (PUKİ>5, EUÖ>10) olarak iki gruba ayrılmışlardır. Daha sonra katılımcıların Prokin PK200 cihazı kullanılarak dinamik denge ölçümleri yapılmıştır. Denge ölçümleri bipedal, sağ ayak üzerinde ve sol ayak üzerinde olmak üzere üç farklı şekilde gözler açık olarak gerçekleştirilmiştir. Ölçümlerin sonunda çevre uzunluğu, alan boşluk yüzdesi, ortalama hız, antero-posterior ortalama denge ve medyo-lateral ortalama denge verileri elde edilmiştir. Verilerin istatistiksel analizi IBM SPSS Statistics Ver. 23 kullanılarak yapılmış, analiz sonucu aritmetik ortalama, standart sapma, frekans dağılımı olarak verilmiş ve analizde Bağımsız Gruplar T-testi, Mann Whitney-U testi kullanılmıştır. Uyku kalitesi ve dinamik denge verileri arasındaki korelasyon analizi için Spearman Korelasyon Analizi kullanılmıştır. İstatistik inceleme sonucu sağ ayak üzerinde ölçülen çevre uzunluğu, sağ ayak üzerinde ölçülen ortalama hız ve sol ayak üzerinde ölçülen alan boşluk yüzdesi değerlerinde iki grup arası istatiksel olarak anlamlı farklar gözlenmiştir ($p<0.05$). Korelasyon analizi incelendiğinde PUKİ ile sağ ayak üzerinde ölçülen çevre uzunluğu arasında istatistiksel olarak anlamlı pozitif yönlü ($r=.269$, $p<0.05$); PUKİ ile sağ ayak üzerinde ölçülen ortalama hız arasında istatistiksel olarak anlamlı pozitif yönlü ($r=.273$, $p<0.05$); PUKİ ile sol ayak üzerinde ölçülen alan boşluk yüzdesi ($r=-.255$, $p<0.05$) arasında istatistiksel olarak anlamlı negatif yönlü korelasyon tespit edilmiştir.

Anahtar Kelimeler: uyku kalitesi, gündüz uykululuğu, postüral kontrol, PUKİ, EUÖ

1. INTRODUCTION AND PURPOSE

Newton's first law states that "an object at rest remains at rest, or if it is in motion, remains in motion at a constant velocity unless it experiences a net external force" (1). In terms of mechanics, this defines the balance (or equilibrium) (2). In a static position, balance is determined by the center of gravity and base of support (BOS) (2). To be balanced, an object's gravity line must fall within the object's BOS; displacement of the line means the object is unbalanced (2). These principles are also applicable to the balance of humans (2).

Postural control is the control of body segments and positions in static or dynamic situations for balance, orientation, and locomotion (3, 4). In other words, it is the body's ability to master its position and movements (5). Maintaining balance is one of the fundamental tasks of the human postural control system (6). For humans, balance is one's ability to stand upright and move without disequilibrium or falling (6). Whether it is static or dynamic, balance is essential for performing most daily activities (7). To maintain postural control and balance, an individual gets various data from the visual system, the vestibular system, the proprioceptive system (8). The information collected is then processed in the central nervous system, and a motor command is sent to the musculoskeletal system (8).

In a situation where the equilibrium of the body is disturbed, the postural control strategies come into play. These strategies may be either reactive or predictive (2). In a reactive postural control strategy, there is a movement or muscular response following an unpredicted disturbance (2). The responses may be fixed-support or change-in-support based on the movement of BOS (2). There are three primary reactive strategies used by healthy people; the ankle strategy (swaying from the ankle), the hip strategy (swaying from the hip), and the stepping strategy (5). While the ankle and the hip strategies are fixed-support strategies, the stepping strategy is a change-in-support strategy (2).

Sleep is very fundamental for human beings, and it nearly takes up one-third of one's lifetime (9). In a sleep state, an organism partly loses contact with its surroundings for a period of time (9). Sleep is a part of an individual's daily life, and in a sleep state, the body renews itself (9). Thus sleep is very important for both physical and mental health (9).

Sleep quality refers to how well an individual sleeps during the night. It can be said; a person has good sleep quality if they feel well-rested, vigorous, and ready to start the day after waking up (9).

Daytime sleepiness is a physiologic need state, and it is a prevalent situation among the population (10), and can be caused by various reasons, such as reduced sleep time, disrupted sleep, or medications (10). Sleepiness often manifests itself as unintended sleep onsets along the day (10).

With sleep deprivation come poor sleep quality and changes in daytime cognitive ability and motor functioning (11); it can affect wakefulness by means of increased sleepiness or reduced alertness (12), and reduce physical activity (13). In addition, it negatively affects power, muscle strength, and speed (14).

Furthermore, there is a link between sleep duration and cardiovascular diseases, gastrointestinal disorders, and likewise, there is a connection between poor sleep quality and increased health complaints (15).

Aguiar and Barela (2015) stated that poor sleep quality alters reaction time, eye-hand coordination and affects postural stability by increasing body sways (16). In another study, Al-Rasheed and Ibrahim (2020) reported that poor sleep significantly impaired postural stability and physical activity in adolescents (17). Furthermore, Furtado et al. (2016) reported that chronic poor sleep quality impairs postural control similarly to total sleep deprivation. They further stated that lack of vision impairs postural balance more deeply in subjects with chronic poor sleep quality (18).

Gooneratne et al. (2003) stated that daytime sleepiness is related to functional impairments in many activities as a result of a decrease in daily functioning in older adults (19). In 2020, Demir et al. reported that daytime sleepiness impairs postural balance in patients with obstructive sleep apnea syndrome (20). Micarelli et al. (2019) stated that daytime sleepiness as a result of poor sleep quality impairs postural control in patients with Marfan syndrome (21). In 2016, Tyagi et al. demonstrated that, in community-dwelling older adults, self-reported daytime sleepiness is related to slow gait speed and poor balance confidence (22).

Although many studies explain the effects of sleep deprivation, poor sleep quality, daytime sleepiness on general health and well-being, a few of them directly looks into the relationship between poor sleep quality and dynamic balance or daytime sleepiness and dynamic balance. In addition, what are the effects of both sleep quality and daytime sleepiness on dynamic balance in a healthy population is still a question.

Therefore, the main aim of this study is to examine the effects of both sleep quality and daytime sleepiness on dynamic balance control in a healthy population.

Two hypotheses were identified in this study:

H_0: There is no difference between the effects of sleep quality and daytime sleepiness on dynamic balance.

H_1: There is a difference between the effects of sleep quality and daytime sleepiness on dynamic balance.

2. GENERAL INFORMATION

2.1. Balance

Equilibrium is defined as a state of balanced forces and torques. As Newton's first law suggests, an object or a body that is either motionless or moving at a constant velocity is in equilibrium (1, 23).

One can examine equilibrium in two different ways as static equilibrium and dynamic equilibrium. Static equilibrium is when the sum of all vertical forces, horizontal forces, and torques is zero. Dynamic equilibrium is when all acting forces on a body result in equal inertial forces in opposite directions. In other words, when a body is entirely motionless, it is in static equilibrium, and when a body is in motion, it is in dynamic equilibrium (23).

The resistance to angular and linear accelerations, in other words, resistance to any mechanical disturbance of equilibrium, is called stability, whereas the ability to control equilibrium is called balance (23). An object is balanced as long as its line of gravity falls on its BOS (2). The line of gravity is referred to as an imaginary line vertically running through center of gravity (COG) (2).

There is a direct relationship between the stability of an object and the displacement of its line of gravity. If an object's line of gravity has to be significantly displaced for it to be unbalanced, that object has more stability (2) (Figure 2.1.).

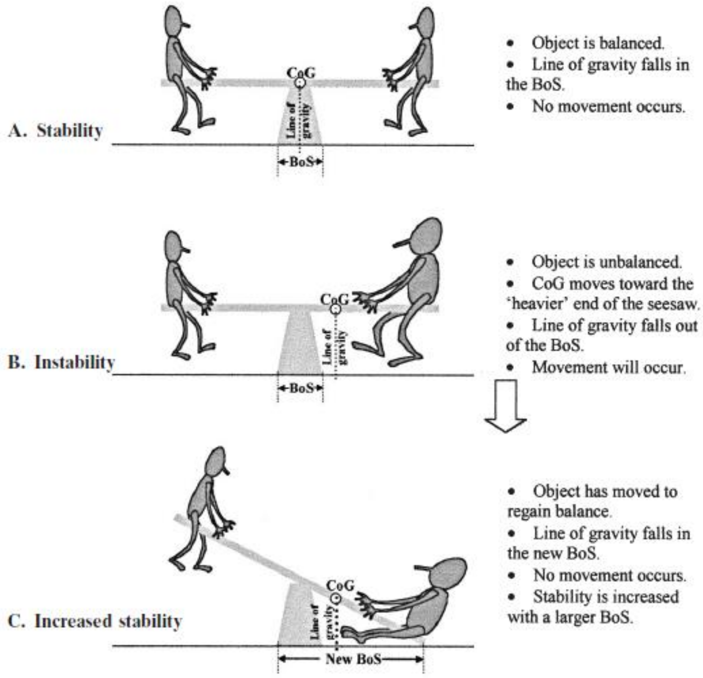

Figure 2.1. Relationship between BOS and the Line of Gravity (2)

This view is also valid for humans (2). In kinesiology, balance defines as one's ability to control their body's position in static and dynamic situations via the collaboration and coordination of many complex systems, and it is a crucial factor for activities and motor skills (24-26). As mentioned above, postural stability is also known as balance and is divided into static and dynamic balance (2, 25).

2.1.1. Static Balance

Static balance is described as keeping the COG within the BOS in situations with minimum motion where the supporting surface does not change, such as sitting and standing upright (27-29). To put it differently, it is preserving the equilibrium of the body while it is in a still position (26). Its development is one of the key features of normal motor development (27).

2.1.2. Dynamic Balance

Dynamic balance allows the body to make adjustments at all stages of movement, either by keeping the COG within the BOS while in motion or restoring the body's equilibrium by altering its positions in a swift sequence (25, 26). Dynamic balance is crucial to avoid injuries that could decrease one's mobility and functionality (30).

2.1.3. Principles of Balance

An object or a person’s static balance depends not only on the acting forces but also on the COG, the line of gravity, and the BOS (3). In order to maintain the balance, the following conditions must be met (24):

1) The BOS must be large,
2) The horizontal distance between the BOS and the line of gravity must be short,
3) The line of gravity must fall within the BOS,
4) The vertical distance between the BOS and the COG must be short.

For the dynamic balance, in addition to these principles, the distance between the opposite point of where the acting force is applied and the COG comes into play (3). If the distance is large, the resistance to the force will be greater (3).

2.2. Postural Control

The term posture is often defined as both the biomechanical alignment of the body and the body’s orientation to the environment (28). Postural control includes the position of the body in space for stability and orientation; it is the body's ability to master its position and movements in static and dynamic situations (5, 28). This complex system’s mechanism has two underlying components, which emerge from many sensorimotor processes: postural orientation and postural stability (25).

2.2.1. Postural Orientation

The ability to properly maintain the relationship between body parts and trunk and environment defines as postural orientation (28, 31). The orientation mechanism is based on interpreting information from the somatosensory, vestibular, and visual systems (25). Body parts’ correct alignment and active control of postural tone are achieved by processing the internal and external inputs (i.e., gravity, supporting surface, visual environment) in the central nervous system (25).

2.2.2. Postural Stability

One’s ability to control the center of mass (COM) or COG within the BOS is called postural stability (2, 28). Postural stability, also referred to as balance, occurs with the coordination of sensorimotor strategies necessary for stabilization during perturbations created by the individual or caused by external factors, and it is divided into static and dynamic balance (25, 31).

The terms COM, COG, or mass centroid are referred to a single imaginary point where all three cardinal planes (sagittal, frontal, and transverse planes) intersect in a body standing in the standard anatomical position (23). COM is the point at which body mass is thought to be evenly distributed in all directions, while COG is the point at which body weight is thought to be evenly distributed in all directions (23, 32). Mass is the matter a body is composed whereas weight is the gravitational force put out on a body (23). The term BOS is the area formed by the furthest parts of the body contacting with the supporting surface (23). Maintaining balance becomes more difficult as the area of the BOS decreases (3, 23).

For people to be able to control their bodies’ positions is crucial in every task (33). Postural control is needed for everything a person does, so every task has an orientation and stability component, and while postural control is needed in every task, stability and orientation needs vary in accordance with the task and the environment (33).

2.2.3. Postural Control System Structures

It is difficult for humans to balance in the standing position because their COGs are higher, and their BOS are narrower than other living things (34). The ability to maintain, gain or regulate a certain balance state is gained by working together with musculoskeletal and neural systems (28, 34). This work-together also depends on the task and the environment where the task is performed (28) (Figure 2.2.).

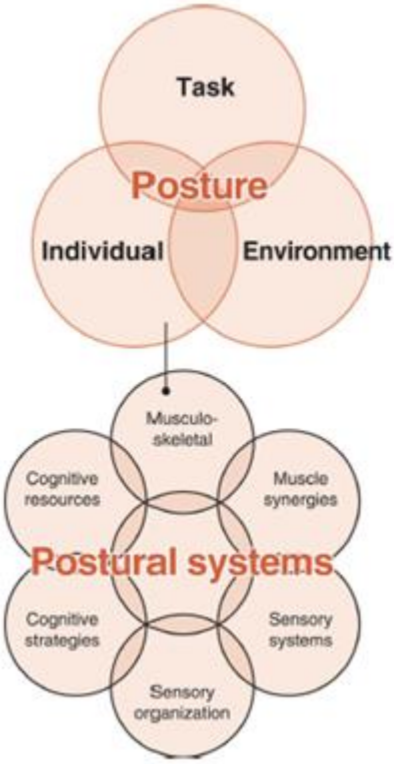

Figure 2.2. Postural Control System Structures (28)

2.2.3.1. Task Constraints

In daily life, people face many different situations that call for three types of balance control. These are steady-state, reactive, and proactive or anticipatory balance (28).

To be able to control the COM within the BOS in anticipated and unchanging situations is called steady-stance balance, whereas to be able to regain stability after an unexpected disturbance is called reactive balance (28). On the other hand, the ability to activate leg and trunk muscles for balance control beforehand the movement is called proactive balance (28). While reactive balance control uses a feedback mechanism, proactive balance control uses a feedforward mechanism (28).

2.2.3.2. Environmental Constraints

Environmental conditions may affect individual systems for postural control. The changed surface, visual, and auditory conditions may have an effect on the organization of the systems for balance control (28).

2.2.3.3. Individual Systems

Postural control arises from the collaboration of musculoskeletal and neural systems (28). While the musculoskeletal aspect includes the range of motion, flexibility, and biomechanics, the neural aspect includes the motor, sensory, and cognitive processes (28).

2.2.4. Neural Components of Postural Control

It includes muscle organization: postural control strategies or movement strategies, sensory process: visual, vestibular, and somatosensory systems, cognitive process: adaptive and anticipatory postural control (28). To maintain postural control, an individual collects various data by the visual system, the vestibular system, the proprioceptive system to process them in the central nervous system and send a motor command to the musculoskeletal system (8).

2.2.4.1. Motor Systems

Motor systems are responsible for producing adequate forces during a task in the right group of muscles for stability and orientation. Apart from force motor neurons and muscles, other systems are included: frontal and motor cortex, brainstem, and spinal network (Figure 2.3.) (28).

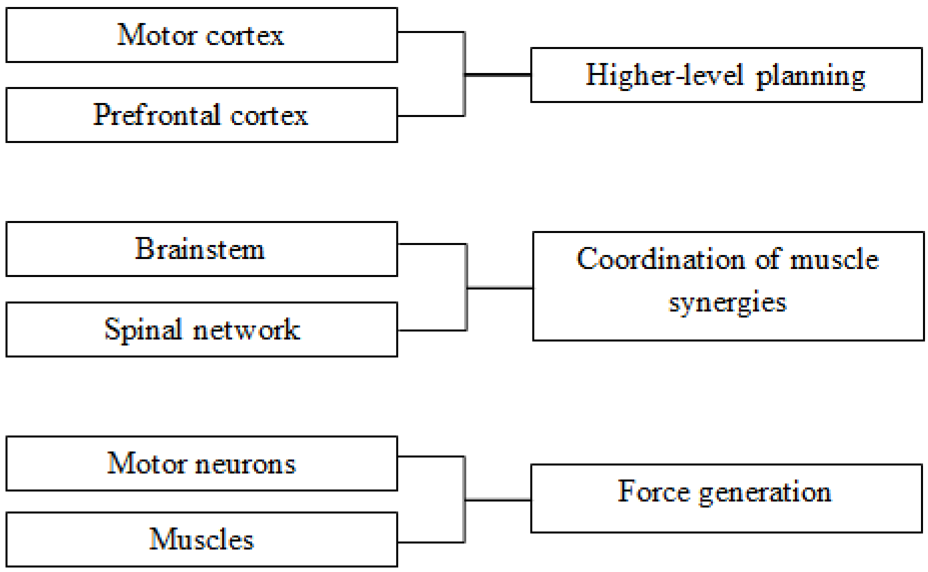

Figure 2.3. Motor Systems (28)

2.2.4.1.A. Postural Control Strategies

While inanimate objects can maintain their balance and stand still within the principles of balance, in living things, postural balance is provided by the postural control strategies or movement strategies formed around the center of pressure (COP), as well as the principles of balance (3). The COP is the center from which the total force exerted on the support surface is distributed and is assumed to be located in the middle of the COM (28). To keep the COM within the BOS, the COP constantly moves (28).

Postural control strategies are divided into two as reactive and proactive or anticipatory, depending on whether there is an unexpected disturbance or a voluntary movement (28, 35). Furthermore, reactive postural control strategies are divided into two as fixed support strategies and change-in-support strategies based on the changes in the BOS (Figure2.4.) (35, 36). As their names suggest, fixed support strategies are when the BOS is not changed during the movement, whereas in change-in-support strategies, there is a replacement of the BOS (31, 35).

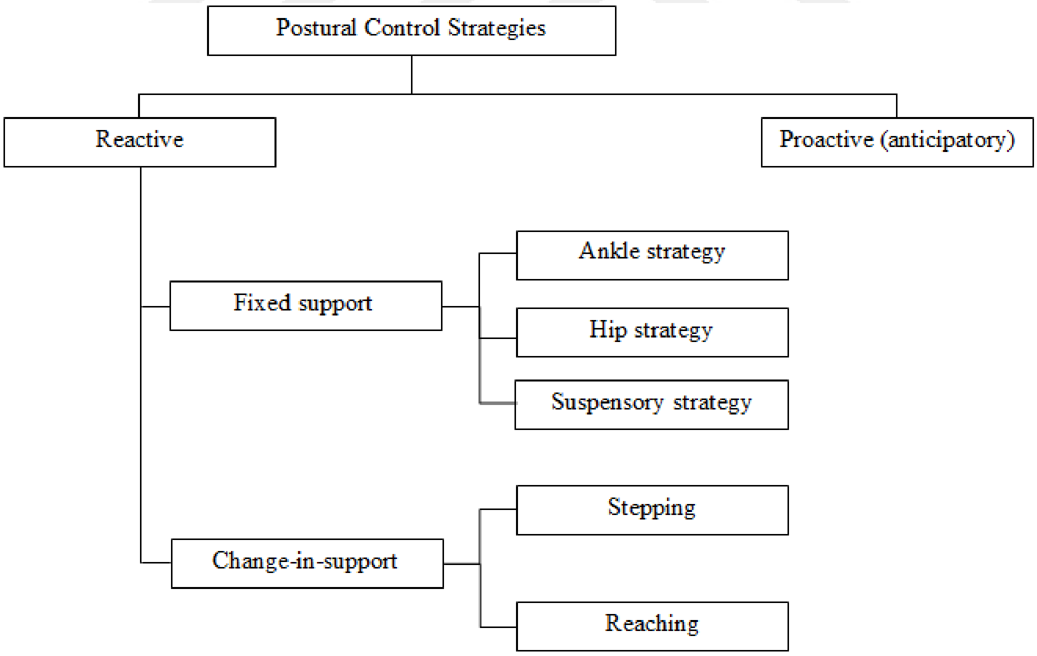

Figure 2.4. Postural Control Strategies

Reactive postural control strategies, reactive movement strategies, or automatic postural responses are activated when there is an unexpected perturbation in the standing position (28, 37). In other words, in reactive strategies, movements and muscle activation occur following an unforeseen disturbance to the balance (25). Reactive strategies are named ankle strategy, hip strategy, stepping strategy, and reach and grasp strategy (Figure 2.5.) (35). In addition to these, there is also the suspensory strategy (37).

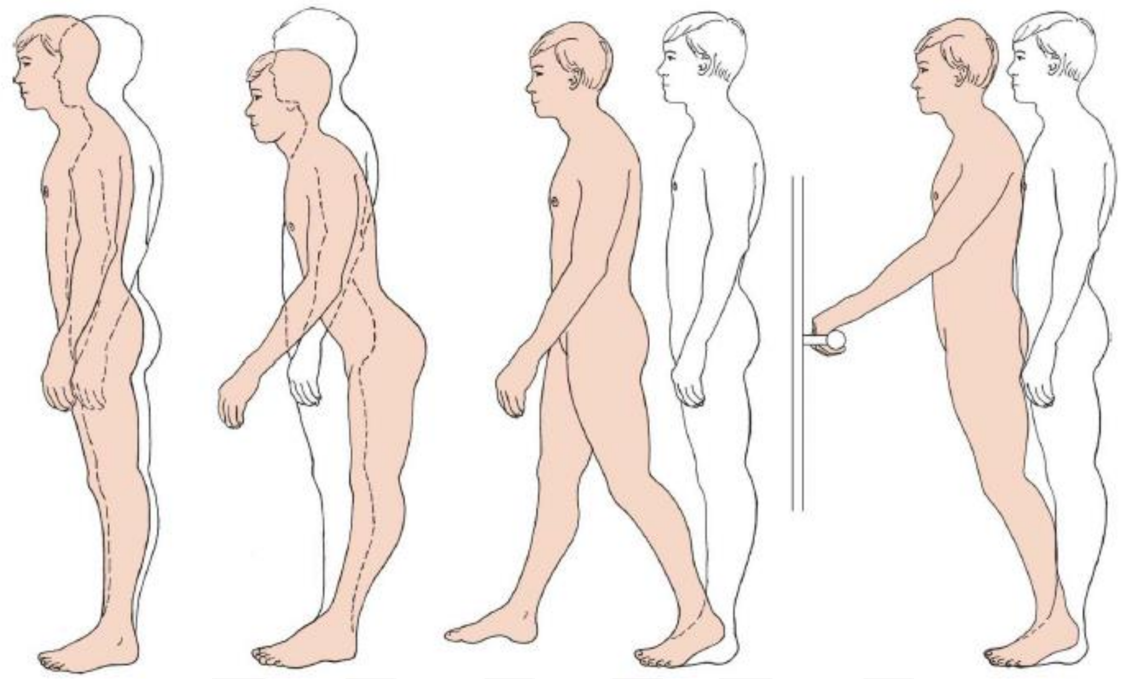

Figure 2.5. Reactive postural control strategies from left: ankle, hip, stepping, and reach and grasp (28)

The ankle, the hip, and suspensory strategies are fixed support strategies. The ankle strategy occurs when the unexpected perturbation is small and slow (28, 37). The movement occurs as small sways at the ankle joint, as the head and the hip move in the same direction (37). The disturbance to the balance is detected by the ankle proprioceptors, and the muscles are activated from distal to proximal (38, 39). It is primarily used in controlling anteroposterior (AP) sway (37).

The hip strategy occurs when the unexpected perturbation is large or fast, and the support surface is narrow (37). The movement occurs at the hip joint, as the head and the hip move in opposite directions (37). The disturbance to the balance is detected by the vestibular system, and the muscles are activated from proximal to distal (38, 39). The hip strategy is used in both AP and mediolateral (ML) sways (37). The suspensory strategy involves lower extremities' bilateral flexion (Figure 2.6.) (37). This way, the distance between BOS and COM shortens, making it easier to control the COM (37).

Figure 2.6. The suspensory strategy (37)

The stepping and the reach and grasp strategies are classified as change-in-support strategies. When the ankle and the hip strategies are not enough to control COM within the BOS, stepping or reach and grasp strategies are used (3, 37). In the reach and grasp strategy, one uses their arms to widen their BOS, whereas, in the stepping strategy, they realign their BOS based on their COM (28).

Proactive postural control strategies occur before the voluntary, planned, or anticipated movements, such as walking, lifting a heavy bag, hanging laundry (35).

In daily life, all postural control strategies are used at the same time and respond to the perturbations in every direction (37).

2.2.4.2. Sensory Systems

There are three sensory systems that take part in postural control; the somatosensory, the visual, and the vestibular systems (39). The body collects various afferent inputs from these systems, and these inputs are then processed at the central nervous system's different levels (40). After this, via efferent pathways, a motor command is sent to many motor neurons for a coordinated movement (40, 41).

2.2.4.2.A. The Visual System

The visual system provides the inputs that supply knowledge of the position and motion of the head, body sway, direction and speed of the motion, body orientation, and potential situations that could cause imbalance (33, 35). The system provides both peripheral and foveal visual information, and among these, peripheral information is more important to control posture (42).

Even though visual inputs are not essential for regular balance, the body's stability gets better by visual inputs (43). However, visual inputs cannot always be trusted as the brain might interpret visual input wrong since the system cannot easily distinguish between exocentric motion (object motion) and egocentric motion (self-motion) (33). For example, when an individual views a car moving in their peripheral vision, they briefly perceive an egocentric motion in the opposite direction (33, 35). When moving, the visual system supplies advanced information about the body's position and environment to avoid any destabilizing situation and plan motor strategies in case of an imbalance (35).

2.2.4.2.B. The Vestibular System

The vestibular system provides inputs of position, motion, and orientation of the head to gravity; these inputs are important for postural control (33, 35). The vestibular apparatus includes the bony labyrinth, the membranous labyrinths, and hair cells, and they are located in the inner ear (Figure 2.7.) (35, 44).

The cochlea, semicircular canals, and otolithic organs form the bony labyrinth, and the membranous labyrinth is contained within it (44). The hollow membranous labyrinth contains a fluid which is called endolymph; the receptors inside this structure are called hair cells (Figure2.7.) (44).

The three hollow fluid-filled rings, the semicircular canals, are located vertically to each other (44). The ampulla are the swellings located one of each semicircular canal's end; they are filled with endolymph and contain crista (hair cells and supporting cells) (Figure 2.7.) (44, 45). When the head moves, semicircular canal receptors perceive the movement via the motion of hair cells in the crista by the shift of endolymph (35, 44). These receptors are responsive to rotational acceleration and deceleration (44).

There are two otolithic organs in the vestibular system; the saccule and the utricle (44). Each of these membranous sacs has a small sensory area located inside of the surface, which is called macula (45). The saccule's macula is located in the vertical plane and responsible for head orientation in a lying position; the utricle's macula is located in the horizontal plane and responsible for head orientation in an upright position (45). The macula consists of hair cells and calcium carbonate crystals called otoliths; when the head is changing position, the otoliths' displacement determines the frequency of neurons' firing (Figure 2.7.) (44). The otolithic organs are sensitive to horizontal and vertical linear acceleration and deceleration and the head's position with respect to gravity (35, 44).

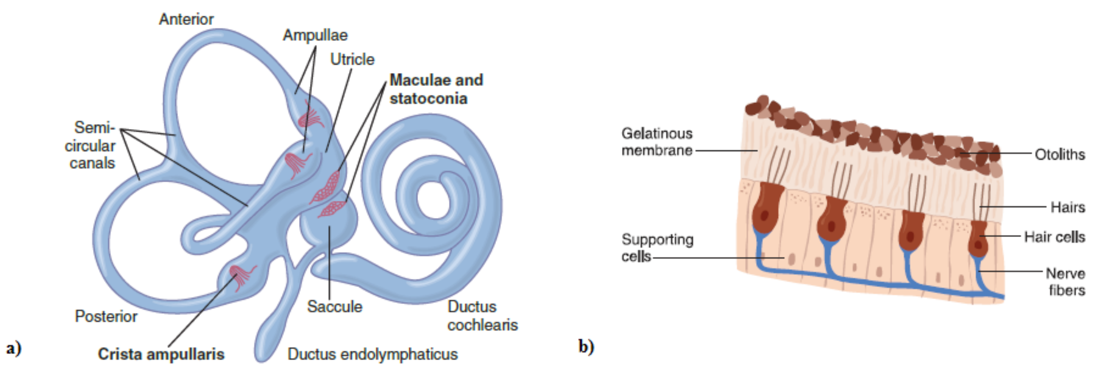

Figure 2.7. a) The vestibular apparatus (45), b) Macula (44)

Vestibular inputs cannot provide clear information about the body's movement in space since the system, alone, cannot distinguish whether the head moves over a stable body or not (35). However, by differentiating a stable surface from an unstable one, the vestibular system helps the somatosensory system to maintain postural control on unstable surfaces (35). In addition to this, the control of the head also depends on the cooperation of these two systems by the vestibulocollic (VCR) and cervico-collic reflexes (CCR) (35).

The VCR is stimulated by the vestibular apparatus, whereas the CCR is stimulated by neck proprioceptors during the motion of the body (46). The VCR stabilizes the gaze by stabilizing the head in space; CCR provides information about the head's movement relative to the body by stabilizing the head on the body (46).

2.2.4.2.C. The Somatosensory System

The somatosensory system provides sensory information from peripheral receptors responsible for the activation of afferent pathways regarding the information about the body's position and movement relative to the support surface and body segments' position relative to each other (34, 40).

Muscle spindles are the mechanoreceptors located throughout the muscle belly (Figure2.8.); these stretch-sensitive receptors are responsible for providing information about muscle length and the contraction velocity; thus, they appear to be important for executing proper voluntary and reflexive movements (40, 45, 47, 48). With the information they are providing, the muscles spindles contribute to kinesthesia and joint position sense, which are collectively called proprioception (40).

The Golgi tendon organ (GTO) is the mechanoreceptor located in the myotendinous junction and the tendons of both ends of the muscle (Figure2.8.) (23, 45). The GTOs are responsive to both active contractions and passive stretches; they are sensitive to the slightest changes in tension within the tendon (44, 49). The GTO, along with joint receptors, provide further afferent information for proprioception (40).

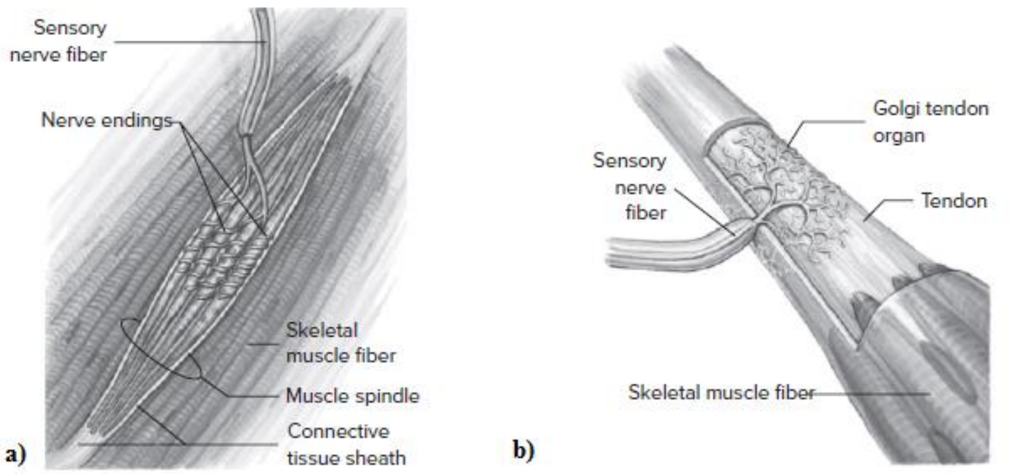

Figure 2.8. a) The muscle spindle (23), b) The golgi tendon organ (23)

Joint receptors or proprioceptors respond to the capsule and the ligaments' mechanical deformations (Figure 2.9.) (44). The Ruffini's endings are located in the joint capsule and respond more to passive movement; the Ruffini's endings get activated by the extremes of joint range (40, 44). Paciniform corpuscles are responsive to movement; when the joint is in a stable position, paciniform corpuscles become silent (44). Like GTO, ligament receptors respond to tension (44). Lastly, there are free nerve endings that often respond to inflammation (44).

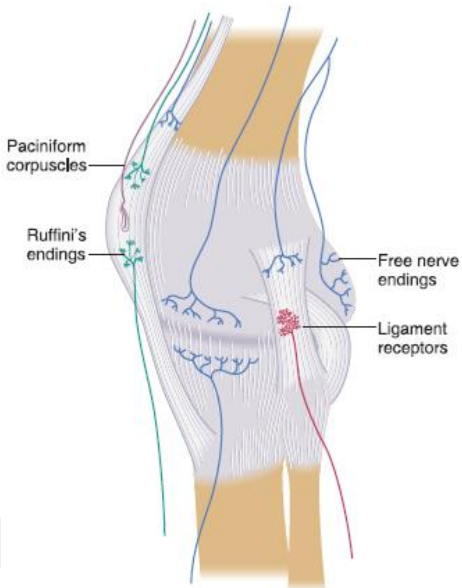

Figure 2.9. Joint receptors (44)

In addition to the ones mentioned above, there are also the cutaneous mechanoreceptors providing important inputs about the environment (40). Even though they are not exactly proprioceptors, the information provided by the cutaneous mechanoreceptors complements the joint position sense and the movement (44).

It has been suggested that since the somatosensory responses to sudden shifts of support surfaces are faster than the visual and vestibular system reactions, the nervous system often prefers the somatosensory inputs to control body sways and to regain balance (28).

2.2.4.2.D. Sensory Integration and Sensory Re-weighting

To be able to maintain postural control, the various sensory inputs from the somatosensory, the visual, and the vestibular systems should be provided and integrated; otherwise, an input from just one system may be misleading (31, 35).

Sensory re-weighting is a mechanism of sensory integration in which the three systems can rearrange weighting based on the changes in the terrain; this process is significant for maintaining postural control throughout the movement (35).

In an illuminated place with a stable surface, a healthy individual gets 70% of sensory input from the somatosensory system, 10% from the visual, and 20% from the vestibular system (50). However, when the surface is unstable, they re-weight by increasing visual and vestibular sensory information and decreasing somatosensory information (51).

2.2.5. Structures Involved in Postural Control

The task to maintain the postural control falls on the nervous system and the musculoskeletal system; any injury or pathology may impair postural control (35).

The spinal cord is enough to keep antigravity support and locomotor functions; however, it is not enough for keeping balance (52). Somatosensory inputs are carried by sensory pathways to the brain, where these inputs are processed, and a motor command is sent; the motor command is again carried in the spinal via motor cord pathways (35, 41).

The brainstem contributes to the control of automatic postural synergies, anticipatory postural control, and postural tone (28). The vestibular nuclei are located in the brainstem, and they are essential for the integration of sensory inputs for postural orientation (35). The vestibular nuclei consist of nucleus vestibularis inferior, nucleus vestibularis superior, nucleus vestibularis lateralis, and nucleus vestibularis medialis (53). While the lateral nucleus participates in postural control, medial and superior nuclei participate in the regulation of the vestibulo-ocular reflex, and the inferior nucleus participates in the integration of impulses from the inner ear and cerebellum (53). The vestibular nuclei, along with the cerebellum, have an important function in the balance and regulation of muscle tone (53).

The cerebellum plays an important role in postural control. The spinocerebellum is the region of the cerebellum where the motor control of the trunk and extremity muscles, the continuation of the movement, and regulation of muscle tone take place (53). Damage to the spinocerabellum results in a way big than usual automatic and anticipatory adjustments, thus impaired postural stability (54). The vestibulocerebellum is the region of the cerebellum where maintaining balance, regulating vestibular reflexes, regulating eye movements, and coordination of head and eye movements take place (53). Damage to the vestibulocerebellum results in difficulty in the orientation of the body with respect to gravity (35).

The basal ganglia are very important for postural control; it is essential for fast changes in postural control strategies and in control of the muscle tone (55).

The cerebral cortex is associated with modification of postural responses with changes in the cognitive stage; furthermore, the cerebral cortex is involved in many aspects of postural control, such as anticipatory postural strategies via supplementary motor cortex (35). It also is involved in the perception of spatial orientation via parietal and temporal areas; thus, damage to any part of the cortex might result in impaired postural control (35). People often perform multiple tasks simultaneously in daily life (28). While performing two tasks at the same time, there might be a reduction in performance on the tasks because of the competition on accessible attentional resources (28). This situation is named dual-task interference (28). The needed cognitive processing is directly proportional to the difficulty of the postural task (56). However, it has been shown that not all secondary tasks can impair postural control in young adults (57, 58).

2.3. Sleep

Just like air, sleep is an essential need for people; however, unlike breathing, people have to act voluntarily to sleep (59). Sleep is described as the unconscious state where the person can be awakened via sensory stimuli (45). It is a brain function and a complex physiologic, organized, and reversible situation (60). It is a multidimensional process and an active state (60).

People spend around 20-40% of their day sleeping; this means roughly one-third of an individual's life is occupied by sleep (59, 61). Lack of sleep can have serious physiological and psychological consequences (45, 61, 62).

Sleep has an important place in quality of life and general health (45, 59, 60). It has been suggested that sleep mainly affects the central nervous system and helps the brain in resting, restoration, recalibration of neural systems, improving cognitive activation, and reinforcing learning (63). In addition, it is known that anabolic hormones like growth hormone, prolactin, and gonadotropin have their levels increase, while the levels of catabolic hormones like cortisol decrease (62). Furthermore, the levels of cytokines like interleukin-1 and tumor necrosis factor-α increase during sleep state (63).

Since sleep is controlled by homeostatic mechanisms, lack of sleep causes sleepiness, increased duration and intensity of sleep, increased amplitude of slow waves, and increased frequency of rapid eye movements when sleeping after the deprivation (62). These effects are not shown in a monotonous manner; instead, they follow a circadian organization (62).

2.3.1 Types of Sleep

Normal sleep has two characteristic phases, alternate with one another during sleep; non-rapid eye movement (NREM) and rapid eye movement (REM) sleep (60). These sleep stages are determined by neurophysiological parameters such as electroencephalogram (EEG), electrooculogram (EOG), and electromyography (EMG) (45, 60).

2.3.1.1. NREM Sleep

NREM sleep, also known as NONREM sleep or slow-wave sleep (SWS), begins with the transition from wakefulness to sleep and progresses to deep sleep (63). NREM sleep is usually referred to as dreamless sleep; however, dreams and nightmares may occur during NREM sleep. NREM sleep period lasts about 90-100 minutes and has four stages; it forms around 75-80% of total sleep time through the night (61, 63). The three stages of NREM are distinguished by the different brain activity (61).

NREM stage 1 (N1) sleep is the stage where the transition between wakefulness to sleep occurs (61). It forms 2-5% of total sleep duration and is easily disrupted by sensory stimuli (61). During N1, mixed-frequency, low-voltage alpha waves can be seen in EEG readings (61, 63). In this stage, breathing is slow and regular, heart rate decreases, and EMG readings of muscle tonus are relatively high (60).

NREM stage 2 (N2) sleep forms 45-55% of total sleep duration, and people often need more strong disruptive stimuli to awaken (61). During N2, mixed-frequency, low-voltage theta waves can be seen in EEG reading; in addition, N2 is characterized by the sleep spindles and K-complexes (60, 61, 63). In this stage, the loss of integrity in thoughts is at the forefront; eye movements usually disappear, and EMG readings of muscle tonus are low as the muscles relax (60).

NREM stage 3 (N3) is often called SWS or deep sleep period, and it is the most restful phase of the sleep cycle (60, 63). N3 forms 20-25% of the total sleep duration (61, 64). During N3, low-frequency, high-voltage slow delta waves can be seen in EEG readings (61, 63). The person, who is tried to be awakened during these stages, often enters in a state of confusion and faces drowsiness or increased sleep inertia (60).

2.3.1.2. REM Sleep

REM sleep (N4), also known as desynchronized or paradoxical sleep, is characterized by rapid eye movement and some atonic skeletal muscles in EMG readings (45, 60). During REM sleep, high-frequency, low-amplitude beta-wave-like desynchronized brain waves can be seen in EEG readings (63). REM sleep forms 20-25% of the total sleep duration, usually lasts about 5-30 minutes in a normal night sleep; when the individual is very tired, the REM period shortens, whereas when they feel rested throughout the sleep duration, the REM period lengthens (45, 64).

REM sleep is often associated with dreaming, and in this period, brain activity is high; as the brain consumes more O_2 and glucose, brain metabolism increases by nearly 20% (45, 63). During REM sleep waking up the person is harder than during SWS; there is muscle atonia, and heart rate and breathing increase and become irregular (45, 60).

2.3.2. Anatomical Structures and Physiologic Changes in Sleep

In sleep physiology, the brainstem is responsible for the secretion of neuromodulators, like, dopamine produced by the substantia nigra, serotonin produced by the dorsal nucleus, norepinephrine produced by the locus coeruleus, and acetylcholine is produced by the basal forebrain (65).

The hypothalamus maintains circadian rhythm since the suprachiasmatic nucleus (SCN) is located here, controls the autonomic nervous system, and by producing histamine in the tuberomammillary nucleus and orexin in the lateral hypothalamus increases the number of neuromodulators (65).

Dopamine, norepinephrine, histamine, and orexin promote wakefulness (65). Serotonin promotes wakefulness, as well as inhibits REM; acetylcholine promotes wakefulness, as well as helps REM sleep (65). Melatonin is secreted by the pineal gland, and it regulates circadian rhythm and promotes sleep (66).

The thalamus acts as a filter by blocking sensory information; this way individual can sleep without being constantly disturbed by surrounding stimuli (65).

Processes like memory, sensory process, and integration, sending motor commands, language, and emotion take place in the cerebrum; thus, even though the cerebrum does not directly take part in the sleep-wake state, the activity of other neurons takes a big part in it (65).

The parasympathetic branch of the autonomic nervous system remains active in NREM sleep; as a result, heart rate and temperature decrease throughout the N1 to the N3(65).

In the sleep state, generally, heart rate and blood pressure decrease; however, momentary increases can be seen in N2 due to K-complexes in the presence of disruptive stimuli or muscle activity (61, 67-69).

When compared with wakefulness, sympathetic-nerve activity increases during REM sleep and decreases throughout the NREM period; however, due to K-complexes, there is a sudden burst in sympathetic-nerve activity during N2 (70).

In the sleep state, breathing decreases in comparison to the wakeful stage; however, throughout the sleep cycle, especially in REM sleep, it can be more erratic (61, 71). Due to reduced muscle tone, both in NREM and REM sleep, situations like hypoventilation and increased airway resistance can be seen (61, 71-73).

When compared to wakefulness, blood flow to the brain and metabolism decreases during NREM sleep; however, compared to NREM and wakeful state, in REM sleep, the flow and metabolism increase in certain parts of the brain, like the limbic system (74, 75).

When it comes to endocrine functions, the changes can be either related to sleep or circadian rhythm (62). For example, the secretion of cortisol is linked with circadian rhythm as it peaks in the early morning even when there is a lack of sleep (62). On the other hand, secretion of growth hormone is linked with sleep and starts during SWS and peaks within the first hours of sleep (62). Apart from growth hormone, secretions of parathyroid hormone, glucose, insulin, and testosterone also increase during sleep (62).

2.3.3. Sleep-Wake Regulation and Circadian Rhythm

Three independent basic mechanisms coordinate sleep and wakefulness: autonomic nervous system, homeostatic sleep continuity, circadian rhythm (60).

The sleep-wake cycle is regulated by a circadian rhythm originating in the SCN of the anterior hypothalamus (60). The circadian rhythm is considered a biological clock (60). The SCN is affected by daylight or light, so when it is naturally dark, the SCN sends a signal to the pineal gland to start melanin secretion (66). The cycle also regulates body temperature; as the sleep time nears, body temperature decreases, by the time it is near to wake, the temperature starts to increase (60, 61).

The homeostatic process is related to the amount of precious sleep and wakefulness (60). Situations like insomnia or interruption of sleep will result in an increase in wakefulness, followed by an increase in sleepiness (60). An increase or decrease in sleep time will thus change homeostatic sleep regulation (60).

Sleep is facilitated by a balancing act in the form of decreased sympathetic activity and increased parasympathetic activity (60). Sympathetic activation may be of endogenous origins, such as anxiety, or it may be of exogenous origins, such as caffeine and nicotine use, and may adversely affect sleep onset (60). Good sleep hygiene and relaxation techniques can provide good autonomic system balancing (60).

In addition to these, the two-process model sleep-wake regulation model (62). In the two-process model, the sleep-wake regulation is provided by sleep homeostasis process S and circadian rhythm process C (62). Process S, as in need of sleeping, builds up throughout the day, reaches its highest right before going to sleep, and diminishes across the night (61). Process C, as in wakefulness and alertness, accumulates throughout the day; yet, decreases before going to sleep (76). When the individual gets enough rest during night sleep, as the need for sleep decreases, waking drive increases (76).

2.3.4. Sleep Quality

Sleep quality refers to how well-rested, fit, and ready to start a new day individual feels after a night's sleep (77). Sleep quality contains both quantitative angles of sleep, like duration and latency, and subjective angles, like depth and restfulness (78). It is an important concept in clinics, as poor sleep quality is common, and it can be an indicator for various medical disorders (78). Poor sleep quality can cause an individual emotional problems (79), an increase in substance use (80, 81), psychological disorders and diseases (82), failure or not being successful enough in academics (83).

2.3.5. Daytime Sleepiness

Sleepiness is a basic physiologic need for survival; it is usually linked to circadian rhythm (84). Daytime sleepiness or excessive daytime sleepiness is a common situation that can be seen in people who cannot get enough sleep (84). Reduced daily sleep time caused by disrupted sleep, sociodemographic factors, like marital status, employment status, and health-related situations, like depression, disease, or medication use, can be listed among the cause of daytime sleepiness (84).

2.4. Sleep and Postural Control

Postural control is essential for daily activities, and one-night sleep deprivation can affect postural stability (85, 86). The vestibular organs related to postural control and hypothalamic structures that are responsible for sleep-wake regulation are connected and in relation with each other (87). Thus, while sleep disorders change oculomotor and postural control related to the vestibular system, pathologies of the vestibular system can disrupt sleep (87). Additionally, situations like social jetlag can cause impaired postural control since it affects areas like the thalamus and cerebellum, which are involved in postural control (88).

Sleep disorders can affect postural control; it has been shown that healthy young adults with poor sleep quality had worse postural control while their eyes were closed (18). In 2009, Ma et al. reported that following a one-night sleep deprivation probably results in a decrease in function of the sensory systems that contribute to postural control, thus resulting in poor postural stability (86). In another study, Martin et al. (2018) showed that one-night sleep deprivation disrupts postural control by dampening the subjective visual vertical perception (89).

Moreover, it has been reported that the effects of sleep deprivation on postural control vary throughout the day (90). In 2011, Bougard et al. reported that postural control of sleep-deprived people was especially affected, in the mid-day, between 10:00 and 14:00 (91); furthermore, in 2014, they reported, people maintain postural control more effectively in the evening (92).

It has been reported by Degache et al. (2016) that sleep-disordered breathing impairs postural control (93). In another study, Gokmen et al. (2021) showed that static postural stability worsens with the increased severity of obstructive sleep apnea (94). In 2019, Micarelli et al. stated that daytime sleepiness results in poor postural control in patients with Marfan syndrome (21). In 2021, Soysal et al. reported that daytime sleepiness is related to fall risks in elderly people with sarcopenia (95). In addition, it has been shown that sleep deprivation accompanied by cognitive demands or old age impairs maintaining postural control while standing (96, 97).

3. MATERIALS AND METHODS

3.1. Participants

The data collection process was carried out between September 2020 and March 2021. In order to carry out this research, written permission was obtained from the Yeditepe University Department of Physiotherapy and Rehabilitation and the Istanbul Gedik University Department of Physiotherapy and Rehabilitation. According to power analysis (0,80 power and 0,05 error) and reference article, 62 participants were enrolled in this study (17). The study protocol was approved by the Yeditepe University Ethical Committee with issue number 37068608-6100-15-1951 (Appendix I).

3.1.1. Inclusion Criteria

Volunteers who were met with the following criteria were included in the study;

- Age between 18 and 35

- To be volunteered to participate

3.1.2. Exclusion Criteria

Volunteers who were met with the following criteria were excluded from the study;

- Lower extremity diseases or dysfunction

- Foot, ankle, or knee trauma or surgery within the past six months

- Otitis

- Neuromuscular coordination impairment

- Presence of sensation deficits, musculoskeletal, neurologic, orthopedic, vestibular, and cardiopulmonary disease

- Body mass index (BMI) over 30 or under 18.5

- Usage of sleep medication or any medication may alter the balance

3.1.3. Study Protocol

67 healthy young adults volunteered to participate in our study. All volunteers were given informed consent (Appendix II). The data was collected from self-report, paper-based questionnaires. Participants were given to Demographic Information Form (Appendix III) to get general information about their sociodemographic and health status; such as age, gender, weight, height and weight, smoking and alcohol habits, usage of assistive devices, existing chronic diseases, physical activity level, and history of lower extremity trauma or injury. Based on their answers, 5 volunteers who were not met the inclusion criteria were excluded.

After the collection of demographic information, the Pittsburgh Sleep Quality Index (PSQI) (Appendix IV) and the Epworth Sleepiness Scale (ESS) (Appendix V) were given to the participants. The included participants were separated into two groups according to their PSQI and ESS scores as the control group (CG) and evaluation group (EG). Participants who simultaneously scored more than 5 in PSQI (78) and more than 10 in ESS (98) were included in EG. Both scores were the cut-off scores of the scales accepted in the literature; PSQI>5 indicates poor sleep quality and ESS>10 indicates daytime sleepiness (78, 98). Participants who simultaneously scored 5 and below in PSQI and 10 and below in ESS were included in CG. After the grouping, all participants' dynamic balance was assessed via Prokin PK200; before the assessment, participants were given the Stanford Sleepiness Scale (SSS) (Appendix VI) to determine their alertness at the time of the Prokin assessment (Figure 3.1.).

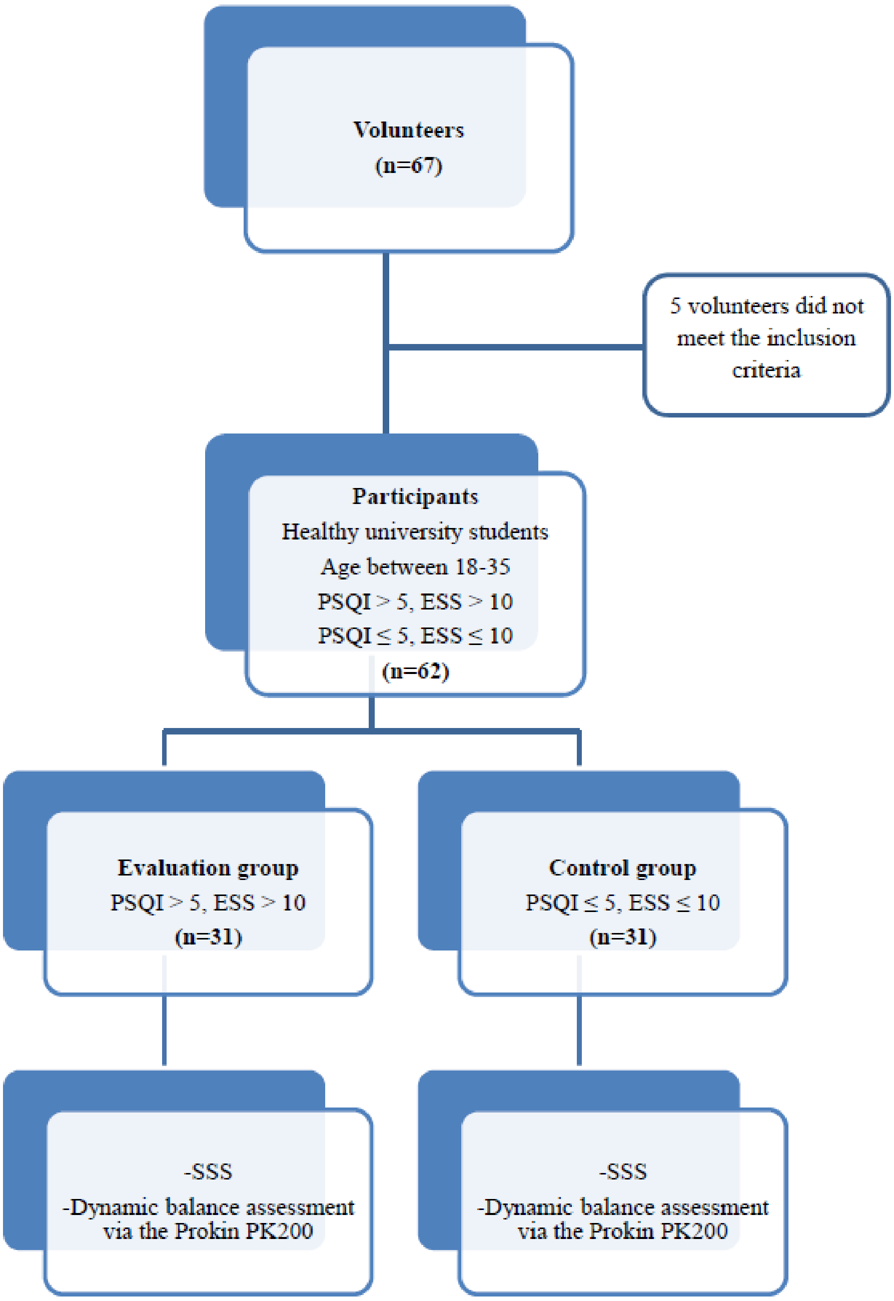

Figure 3.1. Flowchart of the study

3.2. Evaluations

3.2.1. Demographic Information Form

The form is prepared by the researchers and used for obtaining participants' general information, such as age, gender, dominant lower extremity, weight, height, BMI, smoking, and alcohol consumption habits, usage of assistive devices, their activity levels, and the participants' medical history: the presence of any systemic diseases, foot, ankle, or knee trauma or surgery within the past six months.

In our study, participants were first asked to answer demographic information form by themselves. They were asked to answer the questions honestly. During this process, participants' every question was answered without delay. After the collection of demographic information, participants were asked to answer PSQI and ESS.

3.2.2. The Pittsburgh Sleep Quality Index (PSQI)

The PSQI was developed by Buysse et al. in 1989 for subjective sleep quality evaluation over the prior month (78). The questionnaire has 24 questions which 19 of which are self-rated. The remaining 5 questions are answered by a roommate or a bed partner, and they are not used for scoring (99). Questions 1-4 have free-entry responses, whereas questions 5-19 have 4-point Likert scale responses from 0-3 (94). The 19 self-rated items included in scoring are divided into 7 components: subjective sleep quality, sleep latency, habitual sleep efficiency, sleep disturbances, use of medication, and daytime dysfunction (99).

The validity and reliability study for the Turkish Version of the PSQI was conducted by Ağargün et al. (1996); they found the questionnaire's Cronbach α internal consistency coefficient as 0.80 (9), indicating a good level of reliability (100).

In our study, participants were asked to answer PSQI by themselves. Before answering the questions, all participants were told, "The term sleep quality refers to how well a person sleeps at night. The purpose of PSQI is to determine how much quality sleep you have had in the last month; it does not diagnose any sleep problem. Please answer the questions with honesty.". During this process, participants' every question was answered without delay.

In the scoring of PSQI, for component 1, we used the score of question 6. Question 6 is a 4-point Likert scale ranging from 0 (very good) – 3 (very bad). For component 2, the sum of the score of questions 2 and 5a was used; question 2 is a free-entry response ranging from 0 (≤ 15 minutes) – 3 (> 60 minutes), whereas question 5a is a 4-point Likert scale response ranging from 0 (not during the past month) – 3 (three or more times a week). In the calculation of component 3, we used the score of question 4; 4-point Likert response ranging from 0 (≥ 7 hours) – 3 (<5 hours). For component 4, Habitual sleep efficiency (%) = (Hours slept / Hours in bed) x 100 equation was used; based on the result, participants were given scores between 0 (≥ 85%) – 3 (<65%). In the scoring of component 5, the sum of question 5b-j was used. Each subject had a 4-point Likert response from 0 (not during the past month) to 3 (three or more times a week); according to the sum of the scores, participants were given a component score ranging 0 (0) – 3 (19-27). For component 6, the score of question 7 was used; 4-point Likert response ranges from 0 (not during the past month) to 3 (three or more times a week). As for component 7, the sum of scores of questions 8 and 9 was used. Both questions had a 4-point Likert response ranging from 0-3; question 8 0 (not during the past month) – 3 (three or more times a week) and question 9 0 (no problem at all) – 3 (a very big problem). According to the sum of the scores, participants were given a component score ranging from 0 (0) – 3 (5-6). The sum of scores of these 7 components gives a global score between 0 and 21. Participants who scored more than 5 were included in EG, as a global score of more than 5 indicates a poor sleep quality (78, 99).

3.2.3. The Epworth Sleepiness Scale (ESS)

The ESS is an 8-item self-rated questionnaire developed by Johns (1991) to measure daytime sleepiness (101). The questionnaire determines the subjects' general daytime sleepiness in recent times, by asking them their level of "chance of dozing" for 8 particular common circumstances of daily life (99).

The ESS items have 4-point Likert scale responses (99). Each question is scored from 0 to 3 as follows: 0 "would never doze," 1 "slight chance of dozing," 2 "moderate chance of dozing," and 3 "high chance of dozing" (98). The total score ranges between 0-24; scoring a higher point means a higher level of daytime sleepiness, and the cut-off score of the questionnaire is 10 (18, 98).

The validity and reliability study for the Turkish version of the ESS conducted by İzci et al. (2007), they found the questionnaire's Cronbach α internal consistency coefficient as 0.86 in healthy individuals (98), indicating a good level of reliability (100).

In our study, participants were asked to answer ESS by themselves. Before answering the questions, all participants were told "ESS is a questionnaire used to determine the level of daytime sleepiness you have recently. Recently, in your daily life, how often do you sleep in the following situations? Here it should be understood not to feel tired, but to doze or fall asleep. Even if you haven't done any of the following recently, try to think about how such a situation would affect you.”. During this process, participants’ every question was answered without delay.

In scoring, we used the sum of the points of 8 questions; participants who scored more than 10 were included in EG.

3.2.4. The Stanford Sleepiness Scale (SSS)

The SSS is a tool used for subjective measurement of sleepiness developed by Hoddes et al. (1972) (102). Unlike the ESS, the SSS evaluates sleepiness at specific moments in time (103).

The SSS only has one item with seven statements, and it asks subjects to choose one of the seven based on their conditions at the time (104).

In our study, the SSS was only used right before dynamic balance assessment with the purpose of determining the participants' alertness at that exact moment. Participants were first informed about why there is another sleepiness scale and how it differs from the ESS. After that, they were asked “According to this scale, how would you rate your degree of sleepiness at the moment?” and the number corresponding to their answer was marked.

3.2.5. The Prokin PK200

Prokin PK200 is a proprioceptive system with maximum correctness (Figure 3.2). The mobile platform is used for balance assessment and postural training (3, 105). The device is connected to a computer; thus, data collected by the device is transmitted to the computer via a wireless transmitter (105). The device has three multiaxial and one monoaxial difficulty levels (105).

Figure 3.2. Prokin PK200 (105)

In our study, we used the easy multiaxial difficulty level and the equilibrium assessment for the dynamic balance assessment on the right foot, the left foot, and the bipedal stance (106). Each assessment lasted for 30 seconds, and the participants were asked to keep the indicator (the blue plus sign), body's COG, in the reference circle (the red circle) as much as they can (3, 106). As the indicator moved, the data were obtained from the device (Figure 3.3).

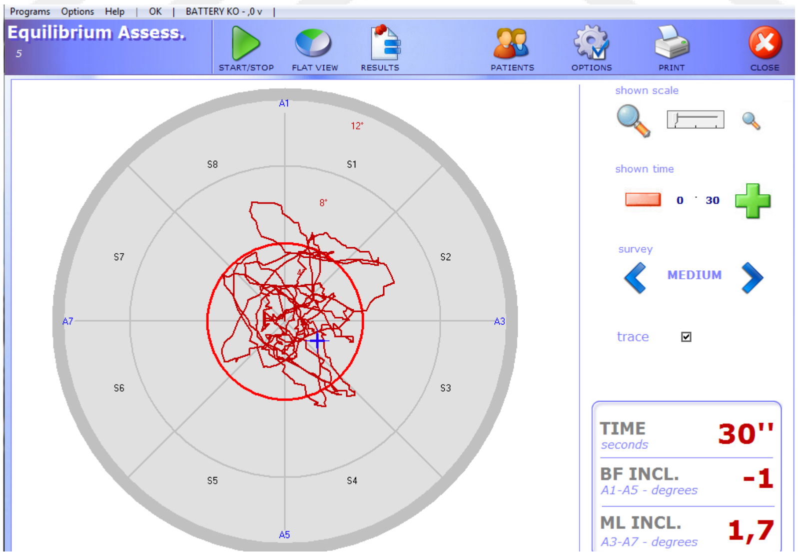

Figure 3.3. Bipedal assessment of participant no5

The assessment process is as follows:

- After the device was connected to a computer, participants were informed and asked to perform the test.

- During the assessment, participants were in a well-lit and quiet environment; before each test, participants were given one trial.
- For bipedal assessment, participants were placed barefooted on the platform, with the feet 8 cm apart, and for the assessments on the right foot and the left foot, participants were asked to place their barefoot on the center of the platform.
- The measurements are done when participants’ eyes are open, and for each measurement, participants were instructed as "Please keep the blue plus sign in the center of the red circle for as long as you can for 30 seconds." (Figure 3.4).
- Whenever the participant moved the indicator out of the reference circle, the device gave an audible warning, and participants were instructed to relocate the indicator in the reference circle.
- Each assessment lasted 30 seconds (90 seconds in total for a participant). At the end of each assessment, the data obtained were recorded by the researcher.

All assessments were undertaken in the same environment by the same researcher. In all assessments, the current measurement was terminated, and the new measurement was started as soon as the participants' feet touched the ground, or they reached and grabbed somewhere.

Figure 3.4. Dynamic balance assessment via Prokin PK200
a) Bipedal b) Right foot c) Left foot

In the equilibrium test, data are obtained from five different parameters. These are as follows:

- Perimeter length (°),
- Area gap percentage (%),
- Medium speed (°/sec),
- Medium equilibrium center-AP (°)
- Medium equilibrium center-ML (°)

The perimeter length is the total degree traveled by the body center of gravity (3). The area gap percentage is the percentage of the area covered by drawing on the surface with respect to the reference circle; it should form a closed loop (3). The medium speed is the average velocity of COG displacement (3). The medium equilibrium center-AP is the mean degree of displacement of the COG in the AP axis (3). The medium equilibrium center-ML is the mean degree of displacement of the COG in the ML axis (3). After each assessment, all the parameters were recorded; in case of missing data, the relevant test was repeated.

3.3. Statistical Analysis

All statistical analyses were performed via IBM SPSS Statistics Ver. 23 (Statistical Package for the Social Sciences, IBM Corp.; Armonk, NY, USA). Descriptive characteristics are presented as mean ± standard deviation ($\bar{X} \pm SD$) or n (%). To determine normal distribution Kolmogorov-Smirnov test was used. For normally distributed variables, the comparisons of the differences between two independent groups were performed by independent sample t-test, whereas, for the variables that did not show a normal distribution Mann-Whitney U test was used. The correlations between sleep quality and dynamic balance assessment variables were calculated with the Spearman test.

In all analyzes, the statistical significance value was accepted as $p<0.05$.

4. RESULTS

Our study concentrated on the effects of sleep quality and daytime sleepiness on postural control; 62 healthy young adults volunteered to participate in the study. The data collection took place between September 2020 and March 2021.

4.1. Demographic Information of Participants

Table 4.1. shows the distribution of quantitative data of demographic characteristics of participants, as age, weight, height, and BMI of CG and EG. There were no statistically significant differences in terms of these variable scores between the groups ($p>0.05$).

Table 4.1. Distribution of quantitative data of demographic characteristics of participants

Measure	**CG** $\bar{X} \pm SD$ **(n=31)**	**EG** $\bar{X} \pm SD$ **(n=31)**	**t**	**p value**
Age (year)	23.10 ± 4.077	22.10 ± 3.124	1.084	.283
Weight (kg)	65.03 ± 12.073	67.32 ± 14.221	-.684	.497
Height (cm)	168.52 ± 7.339	169.94 ± 8.485	-.704	.484
BMI (kg/m^2)	22.82 ± 3.429	23.14 ± 3.672	-.362	.718

CG: Control Group, EG: Evaluation Group, $\bar{X}$: Mean, SD: Standard Deviation, BMI: Body Mass Index

Table 4.2. shows the distribution of qualitative data of demographic characteristics of participants, as gender, the dominant lower extremity, and the smoking, and exercise habits ($p>0.05$).

Table 4.2. Distribution of qualitative data of demographic characteristics of participants

		CG % (n)	EG % (n)	X^2	p value
Gender	Female	48.7 (19)	51.3 (20)	.069	.793
	Male	52.2 (12)	47.8 (11)		
Dominant side in lower extremity	Right	50 (28)	50 (28)	.000	1.0
	Left	50 (3)	50 (3)		
Smoking	No	46.2 (18)	53.8 (21)	.956	.620
	Yes	52.9 (9)	47.1 (8)		
	Cessation	66.7 (4)	33.3 (2)		
Regular exercise	No	47.6 (10)	52.4 (11)	5.124	.275
	Less than 3 days in a month	42.9 (3)	57.1 (4)		
	1-2 times in a week	33.3 (5)	66.7 (10)		
	3-4 times in a week	73.3 (11)	26.3 (4)		
	Everyday	50 (2)	50 (2)		
Duration of one exercise session	Less than 20 minutes	75 (3)	25 (1)	1.448	.836
	21-30 minutes	41.7 (5)	58.3 (7)		
	31-50 minutes	50 (5)	50 (5)		
	More than 50 minutes	53.3 (8)	46.7 (7)		

CG: Control Group, EG: Evaluation Group, X^2: Chi-Square Test

Table 4.3. shows the distribution of the participants' medical history calculated by using Chi-Square test. There were no statistically significant differences between the groups ($p>0.05$).

Table 4.3. Distribution of participants' medical history

		CG % (n)	EG % (n)	X^2	p value
Regularly used medication	No	52.3 (23)	47.7 (21)	.313	.576
	Yes	44.4 (8)	55.6 (10)		
Surgery history	No	53.3 (24)	46.7 (21)	.729	.393
	Yes	41.2 (7)	58.8 (10)		
Assistive devices	No	47.5 (19)	52.5 (21)	.282	.596
	Glasses/contact lens	54.5 (12)	45.5 (10)		
Systemic disease	No	51.4 (19)	48.6 (18)	1.027	.906
	Respiratory diseases	50 (1)	50 (1)		
	Endocrine system disorder	50 (1)	50 (1)		
	Digestive system disorder	0	1 (100)		
	Visual defects	50 (10)	50 (10)		
Lower extremity injury in last 6 months	No	50 (31)	50 (31)	-	-
	Yes	0 (0)	0 (0)		
Lower extremity operations in last 6 months	No	50 (31)	50 (31)	-	-
	Yes	0 (0)	0 (0)		
Ankle sprain in last 6 months	No	50 (31)	50 (31)	-	-
	Yes	0 (0)	0 (0)		

CG: Control Group, EG: Evaluation Group, X^2: Chi-Square Test, - : No statistics are computed because the answer is a constant

4.2. Distribution of Sleep Questionnaire Scores

Table 4.4. shows the distribution of sleep questionnaire scores of control group and evaluation group. There were statistically significant differences in terms of these variable scores between the groups ($p<0.05$).

Table 4.4. Distribution of sleep questionnaire scores

Measure	CG $\bar{X} \pm SD$ (n=31)	EG $\bar{X} \pm SD$ (n=31)	t	p value
PSQI	3.55 ± 1.287	7.97 ± 2.273	-9.421	**.000***
ESS	4.74 ± 2.607	11.81 ± 1.223	-13.659	**.000***
SSS	1.84 ± .860	2.42 ± .992	-2.462	**.017***

CG: Control Group, EG: Evaluation Group, $\bar{X}$: Mean, SD: Standard Deviation, PSQI: Pittsburgh Sleep Quality Index, ESS: Epworth Sleepiness Scale, SSS: Stanford Sleepiness Scale, *$p<0.05$

4.3. Distribution of Prokin Results

Table 4.5. shows the distribution of dynamic balance assessments of control group and evaluation group. There were two variables showed statistically significant differences between the groups: perimeter length assessed on right foot and medium speed assessed on right foot ($p<0.05$).

Table 4.5. Distribution of Prokin results

Measure		CG X̄ ± SD (n=31)	EG X̄ ± SD (n=31)	t	p value
PL (º)	Bipedal	266.13 ± 69.46	298.66 ± 76.89	-1.748	.086
	Right	227.58 ± 53.34	263.01 ± 68.85	-2.265	**.027***
	Left	230.71 ± 84.22	253.65 ± 79.05	-1.106	.273
AGP (%)	Bipedal	13.55 ± 12.78	12.77 ± 8.44	.286	.776
	Right	5.31 ± 3.49	4.20 ± 2.86	1.362	.178
	Left	6.68 ± 3.59	5.12 ± 3.75	1.675	.099
MS (º/sec)	Bipedal	8.86 ± 2.30	9.96 ± 2.58	-1.757	.084
	Right	7.55 ± 1.77	8.76 ± 2.29	-2.330	**.023***
	Left	7.68 ± 2.81	8.45 ± 2.63	-1.118	.268
AP (º)	Bipedal	1.33 ± 1.32	1.09 ± .88	.808	.422
	Right	1.09 ± 1.24	1.27 ± 1.15	-.591	.557
	Left	.88 ± .97	1.11 ± .91	-.990	.326
ML (º)	Bipedal	.88 ± .65	.82 ± .83	.315	.754
	Right	1.27 ± 1.07	1.56 ± 1.10	-1.080	.284
	Left	1.00 ± 1.00	1.11 ± .88	-.475	.637

CG: Control Group, EG: Evaluation Group, X̄: Mean, SD: Standard Deviation, PL: Perimeter Length, AGP: Area Gap Percentage, MS: Medium Speed, AP: Medium Equilibrium Center-Anteroposterior, ML: Medium Equilibrium Center-Mediolateral, *$p<0.05$

4.4. Comparison of Prokin Variables between CG and EG

Table 4.6. shows the comparison of normally distributed variables, perimeter length assessed on bipedal, area gap percentage assessed on right foot, medium speed assessed on

bipedal calculated by using independent sample t-test. Even though there are differences between groups they were not statistically significant (p>0.05).

Table 4.6. Comparison of normally distributed Prokin variables

Measure	**CG** **X̄ ± SD** **(n=31)**	**EG** **X̄ ± SD** **(n=31)**	**t**	**p value**
PL Bipedal (º)	266.13 ± 69.46	298.66 ± 76.89	-1.748	.086
AGP Right (%)	5.31 ± 3.49	4.20 ± 2.86	1.362	.178
MS Bipedal (º/sec)	8.86 ± 2.30	9.96 ± 2.58	-1.757	.084

CG: Control Group, EG: Evaluation Group, X̄: Mean, SD: Standard Deviation, PL: Perimeter Length, AGP: Area Gap Percentage, MS: Medium Speed

Table 4.7. shows the comparison of variables that do not show normal distribution calculated by using Mann Whitney-U test. Even though all variables show differences between groups, only three variables' differences were statistically significant: perimeter length assessed on right foot, area gap percentage assessed on left foot, and medium speed assessed on right foot (p<0.05).

Table 4.7. Comparison of Prokin variables that do not show normally distribution

Measure		CG X̄ ± SD (n=31)	EG X̄ ± SD (n=31)	p value
PL (º)	Right	227.58 ± 53.34	263.01 ± 68.85	**.034***
	Left	230.71 ± 84.22	253.65 ± 79.05	.149
AGP (%)	Bipedal	13.55 ± 12.78	12.77 ± 8.44	.607
	Left	6.68 ± 3.59	5.12 ± 3.75	**.045***
MS (º/sec)	Right	7.55 ± 1.77	8.76 ± 2.29	**.029***
	Left	7.68 ± 2.81	8.45 ± 2.63	.143
AP (º)	Bipedal	1.33 ± 1.32	1.09 ± .88	.773
	Right	1.09 ± 1.24	1.27 ± 1.15	.331
	Left	.88 ± .97	1.11 ± .91	.251
ML (º)	Bipedal	.88 ± .65	.82 ± .83	.414
	Right	1.27 ± 1.07	1.56 ± 1.10	.188
	Left	1.00 ± 1.00	1.11 ± .88	.414

CG: Control Group, EG: Evaluation Group, X̄: Mean, SD: Standard Deviation, PL: Perimeter Length, AGP: Area Gap Percentage, MS: Medium Speed, AP: Medium Equilibrium Center-Anteroposterior, ML: Medium Equilibrium Center-Mediolateral, *p<0.05

4.5. Correlations between Sleep Questionnaire Scores and Prokin Variables

The correlations between all participants sleep questionnaire scores and Prokin variables were calculated by Spearmen test. The calculated data showed us there are positive weak correlations between PSQI and perimeter length assessed on right foot (r=.269, p=.034), medium speed assessed on right foot (r=.273, p=.032), and a negative weak correlation between PSQI and area gap percentage assessed on left foot (r=-.255, p=.046). These are the variables that showed statistically significant difference between two groups (Table 4.8).

Table 4.8. Correlations between PSQI Scores and Prokin variables

	PSQI	
	r	**p**
PL-R (º)	.269	.034
MS-R (º)	.273	.032
AGP-L (%)	-.255	.046

PL-R: Perimeter Length Assesed on Right Foot, MS-R: Medium Speed Assessed on Right Foot, AGP-L: Area Gap Percentage Assessed on Left Foot, r=Correlation Coefficient, *p<0.05

5. DISCUSSION

The objective of our study is to determine the effects of sleep quality and daytime sleepiness on postural control in healthy young adults. With this purpose in mind, participants were asked to answer sleep questionnaires PSQI and ESS. Then participants were divided into two groups (CG and EG) based on their PSQI and ESS score; after the separation, via Prokin PK200, dynamic balance assessment took place for participants.

The statistical analysis showed us there were no statistically significant differences between groups in terms of demographic information of the participants, such as age, gender, height, weight, BMI; these results were parallel to similar studies (17, 18). In addition, there was a statistically significant difference between CG and EG in terms of sleep questionnaire scores. The shown between-group differences of PSQI and SSS were parallel to the studies that used a similar grouping method to our study (17, 107).

In our study, there were meaningful differences between CG and EG in every assessment of perimeter length, as the mean values of perimeter length assessments in EG were higher than the mean values of perimeter length assessments in CG. However, only the right foot assessment showed a statistically significant difference between groups. This might be due to the fact that right foot dominant participants were composed nearly 90% of the overall participants. An increase in perimeter length value indicates poorer postural control; these results were in accordance with our hypothesis. Our findings were parallel to literature; Furtado et al. (2016), analyzed the effects of chronic poor sleep quality in 30 healthy adults (18). They reported that poor sleep quality impairs postural control, as they found overall COG displacements were greater in the poor sleep quality group (18). In addition, Al-Rasheed et al. (2020) conducted a study among 62 healthy adolescents (17). Similar to the literature and our findings, they reported that overall COG displacements were greater in the poor sleep quality group (17).

Moreover, in this study, meaningful differences between CG and EG in every assessment of medium speed were noted. While all mean values of medium speed assessments in EG were higher than the mean values of perimeter length assessments in CG, only the right foot assessment showed a statistically significant difference between groups. This, again, might be due to the fact that the majority of the participants were right foot dominant participants. Higher values in medium speed indicate poorer postural control; thus, these results were supported our hypothesis. In 2016, Degache et al. reported that people with poor sleep quality caused by sleep-disordered breathing showed a greater mean value in their average velocity of COG displacement (93). Moreover, in 2017, Montesinos et al. reported greater average velocities in participants with poor sleep quality in their study (7).

In addition, according to the findings of this study, all assessments of area gap percentage showed meaningful between mean differences, as the mean value of the variable is lower in EG; however, only in left foot assessment, a statistically significant difference can be seen between groups. Nevertheless, in literature, it has been shown that higher area gap percentage values indicate poorer postural control (108, 109). Thus, our hypothesis was not confirmed by these findings. This might be due to increased displacement of COG in AP and ML directions (Table 4.7.). As is mentioned above, the area gap percentage should form a closed-loop; with an increased displacement of COG in AP and ML directions, the said loop's radius might change and cause a decrease in the area calculated.

In accordance with the findings listed above, there were weak positive correlations between PSQI and perimeter length assessed on the right foot, medium speed assessed on the right foot, and a weak negative correlation between PSQI and area gap percentage assessed on the left foot. The positive correlations were in accordance with our hypothesis and with the literature. In 2020, Al-Rasheed et al. conducted their mentioned study to report sleep quality and postural control in healthy adolescents (17). In the study, they divided participants into two groups as poor sleep quality and good sleep quality based on their PSQI scores; similar to our findings, they reported poor postural control in the poor sleep quality group (17). Conversely, in 2021, Saraiva et al. conducted a study to analyze sleep quality and postural control in healthy young adults (110). In the study, they divided participants into two groups as poor sleep quality and good sleep quality based on their PSQI scores and asked the participants to perform cognitive dual tasking during postural control assessment; they reported that the results of postural control assessment were not different between two groups (110). This might be due to the cognitive dual task's effect.

In the present study, mean values of AP and ML sways, in other words, displacement of COG in AP and ML directions, on single leg assessments were showed meaningful differences, as they both were increased. An increase in AP and ML sways indicates poor postural control; however, none of the differences were statistically significant. When the literature is reviewed, it can be seen that poor sleep quality affects AP and ML sways in postural control (17, 18, 88, 111).

These differences that have been observed between the literature and our study might be due to the differences in the study population, the difference in the testing protocol, or the difference in the stability level of the balance platform. Al-Rasheed et al. (2020) and Furtado et al. (2016) both reported in their respective studies that postural control impaired more in people with poor sleep quality as the instability of the balance assessment platform increased (17, 18). Hita-Contreas et al. (2017) showed that in postmenopausal women (112), and Gokmen et al. (2021) reported that in people with obstructive sleep apnea, postural control is affected by sleep quality and daytime sleepiness (94).

There were a few limitations in the present study; first, in our study, the dynamic balance was assessed only with eyes open. Second, dynamic balance assessments were made at only one level of difficulty or instability.

6. CONCLUSION

- Healthy young adults with poor sleep quality and daytime sleepiness have poor postural control on single leg stance.
- There is a correlation between sleep quality and COG displacement.
- Even though they are not statistically significant, AP and ML body sways increased in EG.
- More research is needed to fully understand the effects of poor sleep quality on postural control in young adults with chronic poor sleep quality who are not subject to sleep deprivation.
- The results we found in healthy young adults in our study suggest that problems related to postural control may be included in clinical findings of rehabilitation patients with poor sleep quality. During the rehabilitation process, sleep quality and postural control evaluations, methods to increase sleep quality, and exercises for postural control can be added to the rehabilitation program of the patients. In this way, it can contribute to the quality of life of patients by increasing the effect of rehabilitation.

7. REFERENCES

1. Coelho RL. The law of inertia: How understanding its history can improve physics teaching. *Sci Educ*. 2007;16(9-10):955-974. doi:10.1007/s11191-006-9042-x

2. Pollock AS, Durward BR, Rowe PJ, Paul JP. What is balance? *Clin Rehabil*. 2000;14(4):402-406. doi:10.1191/0269215500cr342oa

3. Inal HS. Spor ve Egzersizde Vücut Biyomekaniği. In: *Spor ve Egzersizde Vücut Biyomekaniği*. Hipokrat Kitabevi; 2017:31-52.

4. Umemura GS, Pinho JP, Santos JPFC, Forner-Cordero A. Assessment of postural control after sleep deprivation with a low-cost portable force plate. *Proc Annu Int Conf IEEE Eng Med Biol Soc EMBS*. Published online 2019:2316-2319. doi:10.1109/EMBC.2019.8857561

5. Kejonen P. *BODY MOVEMENTS DURING POSTURAL STABILIZATION. Measurement with a Motion Analysis System.*; 2002. http://herkules.oulu.fi/isbn9514267931/

6. de Andrade Junior MC, Stefanini R, Gazzola JM, Haddad FLM, Ganança FF. Individuals with peripheral vestibulopathy and poor quality of sleep are at a higher risk for falls. *Braz J Otorhinolaryngol*. 2021;87(4):440-446. doi:10.1016/j.bjorl.2019.10.013

7. Montesinos L, Castaldo R, Cappuccio FP, Pecchia L. Day-to-day variations in sleep quality affect standing balance in healthy adults. *Sci Rep*. 2018;8(1):1-10. doi:10.1038/s41598-018-36053-4

8. Kingma H. Posture , balance and movement : Role of the vestibular system in balance Posture , équilibre , mouvement : caractérisation et conséquences de l ' instabilité motrice au cours de la marche Posture , balance control , movement : Involvement in vestibular. *Neurophysiol Clin Neurophysiol*. 2016;46(4-5):238.

9. Karagozoglu S, Bingöl N. Sleep quality and job satisfaction of Turkish nurses. *Nurs Outlook*. 2008;56(6):298-307.e3. doi:10.1016/j.outlook.2008.03.009

10. Kryger MH, Dement WC, Roth T. *Principles and Practice of Sleep Medicine*. 6th ed. Elsevier; 2017.

11. Bonnet M. Sleep Deprivation. In: Kryger MH, ed. *Principles and Practice of Sleep Medicine.* Saunders Company; 2002:53-71.

12. Wu JC, Gillin JC, Buchsbaum MS, et al. The effect of sleep deprivation on cerebral glucose metabolic rate in normal humans assessed with positron emission tomography. *Sleep*. 1991;14(2):155-162. doi:10.1093/sleep/14.2.155

13. Bromley LE, Booth JN, Kilkus JM, Imperial JG, Penev PD. Sleep restriction decreases the physical activity of adults at risk for type 2 diabetes. *Sleep*. 2012;35(7):977-984. doi:10.5665/sleep.1964

14. Fullagar HHK, Skorski S, Duffield R, Hammes D, Coutts AJ, Meyer T. Sleep and Athletic Performance: The Effects of Sleep Loss on Exercise Performance, and Physiological and Cognitive Responses to Exercise. *Sport Med*. 2015;45(2):161-186. doi:10.1007/s40279-014-0260-0

15. Pilcher JJ, Ginter DR, Sadowsky B. Sleep quality versus sleep quantity: Relationships between sleep and measures of health, well-being and sleepiness in college students. *J Psychosom Res*. 1997;42(6):583-596. doi:10.1016/S0022-3999(97)00004-4

16. Aguiar SA, Barela JA. Adaptation of sensorimotor coupling in postural control is impaired by sleep deprivation. *PLoS One*. 2015;10(3):1-14. doi:10.1371/journal.pone.0122340

17. Al-Rasheed AS, Ibrahim AI. Does the poor sleep quality affect the physical activity level, postural stability, and isometric muscle strength in Saudi adolescents? A comparative study. *Saudi Med J*. 2020;41(1):94-97. doi:10.15537/smj.2020.1.24761

18. Furtado F, Gonçalves BDSB, Abranches ILL, Abrantes AF, Forner-Cordero A. Chronic low quality sleep impairs postural control in healthy adults. *PLoS One*. 2016;11(10):1-13. doi:10.1371/journal.pone.0163310

19. N.S. G, T.E. W, J.R. C, et al. Functional outcomes of excessive daytime sleepiness in older adults. *J Am Geriatr Soc*. 2003;51(5):642-649. http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L36541428%5Cnhttp://dx.doi.org/10.1034/j.1600-0579.2003.00208.x%5Cnhttp://sfx.library.uu.nl/utrecht?sid=EMBASE&issn=00028614&id=doi:10.1034/j.1600-0579.2003.00208.x&atitle=Functional

20. Demir T, Aslan K, Demirkiran M. Evaluation of postural balance in patients with obstructive sleep apnoea syndrome. *Neurol Neurochir Pol*. 2020;54(1):83-89. doi:10.5603/PJNNS.a2019.0059

21. Micarelli A, Viziano A, Lanzillotta A, et al. Postural control abnormalities related to sleep deprivation in patients with Marfan Syndrome. *J Vestib Res Equilib Orientat*. 2019;29(5):261-269. doi:10.3233/VES-190684

22. Tyagi S, Perera S, Brach JS. Balance and Mobility in Community-Dwelling Older Adults: Effect of Daytime Sleepiness. *J Am Geriatr Soc*. 2017;65(5):1019-1025. doi:10.1111/jgs.14735

23. Hall SJ. *BASIC BIOMECHANICS*. 8th ed. McGraw-Hill Education; 2019.

24. Knudson D. *Fundamentals of Biomechanics*. 3rd ed. Springer Nature; 2013. doi:10.1201/b14767

25. Onursal-Kılınç O. Postüral Kontrol ve Denge Egzersizleri. In: Aksoy S, ed. *Temel Vestibüler Rehabilitayson*. Hipokrat Kitabevi; 2020:39-43.

26. Davlin CD. Dynamic balance in high level athletes. *Percept Mot Skills*. 2004;98(3 II):1171-1176. doi:10.2466/pms.98.3.1171-1176

27. Geuze RH. Static balance and developmental coordination disorder. *Hum Mov Sci*. 2003;22(4-5):527-548. doi:10.1016/j.humov.2003.09.008

28. Shumway-Cook A, Woollacott MH. *Motor Control Translating Research into Clinical Practice*. 5th ed. Wolters Kluwer; 2017.

29. C H. Balance ability and athletic performance. *Sport Med*. 2011;41(3):221-232.

30. Neptune RR, Vistamehr A. Dynamic balance during human movement: Measurement and control mechanisms. *J Biomech Eng*. 2019;141(7):1-10. doi:10.1115/1.4042170

31. Horak FB. Postural orientation and equilibrium: What do we need to know about neural control of balance to prevent falls? *Age Ageing*. 2006;35(SUPPL.2):7-11. doi:10.1093/ageing/afl077

32. Chapman AE. *Biomechanical Analysis of Fundamental Human Movements*. Human Kinetics; 2008.

33. Shumway-Cook A, Woollacott M. *MOTOR CONTROL TRANSLATING RESEARCH INTO CLINICAL PRACTICE FOURTH EDITION Motor Control Motor Control*. 4th ed.; 2012. http://www.lww.com.

34. Ergin MS. Denge, Koordinasyon ve Propriyosepsiyon. In: Kaya Utlu D, ed. *Fizyoterapistler İçin İşlevsel Egzersiz Anatomisi ve Fizyolojisi*. Hipokrat Kitabevi; 2021:409-422.

35. Horak FB. Postural Control. *Encycl Neurosci*. Published online 2009:3212-3219. doi:10.1007/978-3-540-29678-2_4708

36. Maki BE. Postural Strategies. *Encycl Neurosci*. Published online 2009:3222-3227. doi:https://doi.org/10.1007/978-3-540-29678-2_4714

37. Umphred DA, Burton GU, Lazaro RT, Roller ML. *Umphred's Neurological Rehabilitation*. 6th ed. Elsevier; 2013. doi:10.1016/b978-0-323-07586-2.00023-6

38. Horak FB, Nashner LM. Central programming of postural movements: Adaptation to altered support-surface configurations. *J Neurophysiol*. 1986;55(6):1369-1381. doi:10.1152/jn.1986.55.6.1369

39. Horak FB, Nashner LM, Diener HC. Postural strategies associated with somatosensory and vestibular loss. *Exp Brain Res*. 1990;82(1):167-177. doi:10.1007/BF00230848

40. Shaffer SW, Harrison AL. Aging of the somatosensory system: A translational perspective. *Phys Ther*. 2007;87(2):193-207. doi:10.2522/ptj.20060083

41. Kingma H. Posture, balance and movement: Role of the vestibular system in balance control during stance and movements. *Neurophysiol Clin Neurophysiol*. 2016;46(4-5):238. doi:10.1016/j.neucli.2016.09.005

42. Paillard T, Noé F. Effect of expertise and visual contribution on postural control in soccer. *Scand J Med Sci Sport*. 2006;16(5):345-348. doi:10.1111/j.1600-0838.2005.00502.x

43. Guerraz M, Bronstein AM. Ocular versus extraocular control of posture and equilibrium. *Neurophysiol Clin*. 2008;38(6):391-398. doi:10.1016/j.neucli.2008.09.007

44. Lundy-Ekman L. *Neuroscience Fundamentals for Rehabilitation*. 5th ed. Elsevier; 2018.

45. Hall JE, Guyton AC. *Guyton and Hall Textbook of Medical Physiology*. 13th ed. Elsevier; 2016.

46. Keshner EA. Vestibulocollic and Cervicocollic Control. *Encycl Neurosci*. Published online 2009:4220-4224. doi:https://doi.org/10.1007/978-3-540-29678-2_6308

47. Prochazka A. Muscle spindle function during normal movement. *Int Rev Physiol*. 1981;25:47-90.

48. McIlroy WE, Maki BE. Age-related changes in compensatory stepping in response to unpredictable perturbations. *Journals Gerontol - Ser A Biol Sci Med Sci*. 1996;51(6):289-296. doi:10.1093/gerona/51A.6.M289

49. Chalmers G. Strength training: Re-examination of the possible role of golgi tendon organ and muscle spindle reflexes in proprioceptive neuromuscular facilitation muscle stretching. *Sport Biomech*. 2004;3(1):159-183. doi:10.1080/14763140408522836

50. Peterka RJ. Sensorimotor integration in human postural control. *J Neurophysiol*. 2002;88(3):1097-1118. doi:10.1152/jn.2002.88.3.1097

51. Peterka RJ, Loughlin PJ. Dynamic Regulation of Sensorimotor Integration in Human Postural Control. *J Neurophysiol*. 2004;91(1):410-423. doi:10.1152/jn.00516.2003

52. Macpherson JM, Fung J. Weight support and balance during perturbed stance in the chronic spinal cat. *J Neurophysiol*. 1999;82(6):3066-3081. doi:10.1152/jn.1999.82.6.3066

53. Taner D. *Fonksiyonel Nöroanatomi*. 23rd ed. ODTÜ Yayıncılık; 2020.

54. Horak FB, Diener HC. Cerebellar Control of Postural Scaling and Central Set in Stance. *J Neurophysiol*. 1994;72(2):479-493. doi:https://doi.org/10.1152/jn.1994.72.2.479

55. Horak FB, Frank J, Nutt J. Effects of dopamine on postural control in parkinsonian subjects: Scaling, set, and tone. *J Neurophysiol*. 1996;75(6):2380-2396. doi:10.1152/jn.1996.75.6.2380

56. Teasdale N, Simoneau M. Attentional demands for postural control: The effects of aging and sensory reintegration. *Gait Posture*. 2001;14(3):203-210. doi:10.1016/S0966-6362(01)00134-5

57. Stoffregen TA, Pagulayan RJ, Bardy BG, Hettinger LJ. Modulating postural control to facilitate visual performance. *Hum Mov Sci*. 2000;19(2):203-220. doi:https://doi.org/10.1016/S0167-9457(00)00009-9

58. Andersson G, Hagman J, Talianzadeh R, Svedberg A, Larsen HC. Effect of cognitive load on postural control. *Brain Res Bull*. 2002;58(1):135-139. doi:10.1016/S0361-9230(02)00770-0

59. Grandner MA. Sleep, Health, and Society. *Sleep Med Clin*. 2020;15(2):319-340. doi:10.1016/j.jsmc.2020.02.017

60. BORA İH, BİCAN A, Physiology THE, Sleep OF. Uyku Fizyolojisi. *Turkiye Klin J Surg Med Sci*. 2007;3(23):1-6.

61. Colten HR, Altevogt BM. *Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem*. 1st ed. The National Academics Press; 2006. doi:10.17226/11617

62. ALDRICH MS. *SLEEP MEDICINE*. Oxford University Press; 1999.

63. Pınar L. *Sinir Sistemi ve Kas Fizyolojisi Temel Bilgileri*. 5th ed. Akademisyen Kitabevi; 2018. https://www.nobelkitabevi.com.tr/fiziksel-tip-ve-rehabilitasyon/8976-sinir-sistemi-ve-kas-fizyolojisi-temel-bilgileri-9786052586327.html

64. Ulukavak Çiftçi T. *Türk Toraks Derneği Obstrüktif Uyku Apne Sendromu Tani ve Tedavi Uzlaşı Raporu*. Vol 13.; 2012.

65. Tubbs AS, Dollish HK, Fernandez F, Grandner MA. *The Basics of Sleep Physiology and Behavior*. Elsevier Inc.; 2019. doi:10.1016/B978-0-12-815373-4.00001-0

66. Comai S, Lopez-Canul M, De Gregorio D, et al. Melatonin MT1 receptor as a novel target in neuropsychopharmacology: MT1 ligands, pathophysiological and therapeutic implications, and perspectives. *Pharmacol Res*. 2019;144(April):343-356. doi:10.1016/j.phrs.2019.04.015

67. Catcheside PG, Orr RS, Chiong SC, Mercer J, Saunders NA, McEvoy RD. Noninvasive cardiovascular markers of acoustically induced arousal from non-rapid-eye-movement sleep. *Sleep*. 2002;25(7):797-804. doi:10.1093/sleep/25.7.797

68. Blasi A, Jo J, Valladares E, Morgan BJ, Skatrud JB, Khoo MCK. Cardiovascular variability after arousal from sleep: Time-varying spectral analysis. *J Appl Physiol*. 2003;95(4):1394-1404. doi:10.1152/japplphysiol.01095.2002

69. Tank J, Diedrich A, Hale N, et al. Relationship between blood pressure, sleep K-complexes, and muscle sympathetic nerve activity in humans. *Am J Physiol - Regul Integr Comp Physiol*. 2003;285(1 54-1):208-214. doi:10.1152/ajpregu.00013.2003

70. Somers VK, Dyken ME, Mark AL, Abboud FM. Sympathetic-Nerve Activity during Sleep in Normal Subjects. *N Engl J Med*. 1993;328(5):303–307. doi:doi:10.1056/nejm199302043280502

71. Krieger J. Respiratory physiology: Breathing in normal subjects. In: Kryger MH, Dement WC, Roth T, eds. *Principles and Practice of Sleep Medicine*. 4th ed. Elsevier Saunders; 2000:229 – 241.

72. Woods SL, Froelicher ESS, Motzer SA, Bridges EJ. Cardiac nursing: Sixth edition. *Card Nurs Sixth Ed*. Published online 2011:1-955.

73. Douglas NJ. Respiratory physiology: Control of ventilation. In: Kryger MH, Dement WC, Roth T, eds. *Principles and Practice of Sleep Medicine*. 4th ed. Elsevier Saunders; 2005:224 – 229.

74. Madsen PL, Holm S, Vorstrup S, Friberg L, Lassen NA, Wildschiødtz G. Human regional cerebral blood flow during rapid-eye-movement sleep. *J Cereb Blood Flow Metab*. 1991;11(3):502-507. doi:10.1038/jcbfm.1991.94

75. Madsen PL, Schmidt JF, Wildschiodtz G, et al. Cerebral O2 metabolism and cerebral blood flow in humans during deep and rapid-eye-movement sleep. *J Appl Physiol*. 1991;70(6):2597-2601. doi:10.1152/jappl.1991.70.6.2597

76. Gillette M, Abbott S. Fundamentals of the circadian system. In: *Sleep Research Society. SRS Basics of Sleep Guide*. Sleep Research Society; 2005:131 – 138.

77. Şenol V, Soyuer F, Pekşen Akça R, Argün M. Adolesanlarda Uyku Kalitesi ve Etkileyen Faktörler. *Kocatepe Med J*. 2012;(1):93-102.

78. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28:193–213. Published online 1989.

79. Verlander LA, Benedict JO, Hanson DP. Stress and sleep patterns of college students. *Percept Mot Skills*. 1999;88(3 Pt 1):893-898. doi:https://doi.org/10.2466/pms.1999.88.3.893

80. Curcio G, Ferrara M, De Gennaro L. Sleep loss, learning capacity and academic performance. *Sleep Med Rev*. 2006;10(5):323-337. doi:10.1016/j.smrv.2005.11.001

81. Sarı ÖY, Üner S, Büyükakkuş B, Bostancı EÖ, Çeliksöz AH, Budak M. Sleep quality and some factors affecting sleep quality in the students living in the residence hall of a university | Bir üniversitenin yurtta kalan öğrencilerinde uyku kalitesi ve etkileyen bazı faktörler. *TAF Prev Med Bull*. 2015;14(2):93-100. doi:10.5455/pmb1-1408013434

82. Liu X, Zhao Z, Jia C, Buysse DJ. Sleep patterns and problems among chinese adolescents. *Pediatrics*. 2008;121(6):1165-1173. doi:10.1542/peds.2007-1464

83. Yilmaz D, Tanrikulu F, Dikmen Y. Research on Sleep Quality and the Factors Affecting the Sleep Quality of the Nursing Students. *Curr Heal Sci J*. 2017;43(1):20-24. doi:10.12865/CHSJ.43.01.03

84. Roehrs T, Carskadon MA, Dement WC, Roth T. Daytime Sleepiness and Alertness. In: Kryger MH, Dement WC, Roth T, eds. *Principles and Practice of Sleep Medicine*. 6th ed. ; 2017:39-48.

85. Ku PX, Abu Osman NA, Yusof A, Abas WAB. The effect on human balance of standing with toe-extension. *PLoS One*. 2012;7(7):1-5. doi:10.1371/journal.pone.0041539

86. Ma J, Yao YJ, Ma RM, et al. Effects of sleep deprivation on human postural control, subjective fatigue assessment and psychomotor performance. *J Int Med Res*. 2009;37(5):1311-1320. doi:10.1177/147323000903700506

87. Besnard S, Tighilet B, Chabbert C, et al. The balance of sleep: Role of the vestibular sensory system. *Sleep Med Rev*. 2018;42:220-228. doi:10.1016/j.smrv.2018.09.001

88. Umemura GS, Pinho JP, Da Silva Brandão Gonçalves B, Furtado F, Forner-Cordero A. Social jetlag impairs balance control. *Sci Rep*. 2018;8(1):1-7. doi:10.1038/s41598-018-27730-5

89. Martin T, Gauthier A, Ying Z, et al. Effect of sleep deprivation on diurnal variation of vertical perception and postural control. *J Appl Physiol*. 2018;125(1):167-174. doi:10.1152/japplphysiol.00595.2017

90. Gribble PA, Hertel JAY. Changes in Postural Control During a 48-Hr. Sleep Deprivation Period. *Percept Mot Skills*. 2004;99(3 Pt 1):1035-1045. doi:https://doi.org/10.2466/pms.99.3.1035-1045

91. Bougard C, Lepelley MC, Davenne D. The influences of time-of-day and sleep deprivation on postural control. *Exp Brain Res*. 2011;209(1):109-115. doi:10.1007/s00221-010-2524-8

92. Bougard C, Davenne D. Morning/evening differences in somatosensory inputs for postural control. *Biomed Res Int*. 2014;2014. doi:10.1155/2014/287436

93. Degache F, Goy Y, Vat S, Rubio JH, Contal O, Heinzer R. Sleep-disordered breathing and daytime postural stability. *Thorax*. 2016;71(6):543-548. doi:10.1136/thoraxjnl-2015-207490

94. Yilmaz Gokmen G, Gurses HN, Zeren M, Ozyilmaz S, Kansu A, Akkoyunlu ME. Postural stability and fall risk in patients with obstructive sleep apnea: a cross-sectional study. *Sleep Breath*. 2021;25(4):1961-1967. doi:10.1007/s11325-021-02322-2

95. Soysal P, Smith L, Tan SG, Capar E, Veronese N, Yang L. Excessive daytime sleepiness is associated with an increased frequency of falls and sarcopenia. *Exp Gerontol*. 2021;150(March):111364. doi:10.1016/j.exger.2021.111364

96. Schlesinger A, Redfern MS, Dahl RE, Jennings JR. Postural control, attention and sleep deprivation. *Neuroreport*. 1998;9(1):49-52. doi:10.1097/00001756-199801050-00010

97. Robillard R, Prince F, Filipini D, Carrier J. Aging worsens the effects of sleep deprivation on postural control. *PLoS One*. 2011;6(12):1-7. doi:10.1371/journal.pone.0028731

98. Izci B, Ardic S, Firat H, Sahin A, Altinors M, Karacan I. Reliability and validity studies of the Turkish version of the Epworth Sleepiness Scale. *Sleep Breath*. 2008;12(2):161-168. doi:10.1007/s11325-007-0145-7

99. Omachi TA. Measuring Sleep in Rheumatologic Diseases: The ESS, FOSQ, ISI, and PSQI. *Arthritis Care Res*. 2013;31(3):477-479. doi:10.1002/acr.20544.Measuring

100. Kilic S. Cronbach's alpha reliability coefficient. *J Mood Disord*. 2016;6(1):47. doi:10.5455/jmood.20160307122823

101. Johns MW. A new method for measuring daytime sleepiness: The Epworth sleepiness scale. *Sleep*. 1991;14(6):540-545. doi:10.1093/sleep/14.6.540

102. Hoddes E, Zarcone V, Smythe H, Phillips R, Dement WC. Hoddes_1973_quantification of sleepiness.pdf. Published online 1972:431-436.

103. Johns MW. Sensitivity and specificity of the MSLT, the MWT and the ESS. Failure of the MSLT as a gold standard. *J Sleep Res*. 2000;9:5-11.

104. Shahid A, Wilkinson K, Marcu S, Shapiro CM. stanford sleepiness scale. *STOP, THAT One Hundred Other Sleep Scales*. Published online 2012:1-406. doi:10.1007/978-1-4419-9893-4

105. DataTeknik. PK200 Portatif Kablosuz Dinamik Denge Ölçüm Sistemi. http://datateknikmed.com/urun/pk200-portatif-kablosuz-dinami-denge-olcum-sistemi/

106. Birinci T, Demirbas SB. Relationship between the mobility of medial longitudinal arch and postural control. *Acta Orthop Traumatol Turc*. 2017;51(3):233-237. doi:10.1016/j.aott.2016.11.004

107. Park S, Park J-A, Park K, Kim J-H, Hong Y. Effects of Sleep on Balance Control and Reaction Time to Visual Stimuli. *Sleep Med Psychophysiol*. 2016;23(2):68-76. doi:10.14401/kasmed.2016.23.2.68

108. KESİLMİŞ İ, AKIN M. Dynamic Balance Ability and Hypermobility In Pre-School Children Who Participate Gymnastic Training. *Gaziantep Üniversitesi Spor Bilim Derg*. 2018;3(3):78-87. doi:10.31680/gaunjss.453979

109. Kesilmis I. The Comparison of the Different Balance Performance of Soccer Players Versus Sedentary. *Int J Sport Sci Phys Educ*. 2017;2(3):37. doi:10.11648/j.ijsspe.20170203.11

110. Saraiva M, Marouvo J, Fernandes O, Castro MA, Vilas-Boas JP. Postural Control and Sleep Quality in Cognitive Dual Tasking in Healthy Young Adults. *J*. 2021;4(3):257-265. doi:10.3390/j4030021

111. Smith SS, Cheng T, Kerr GK. The effect of extended wake on postural control in young adults. *Exp Brain Res*. 2012;221(3):329-335. doi:10.1007/s00221-012-3175-8

112. Hita-Contreras F, Zagalaz-Anula N, Martínez-Amat A, et al. Sleep quality and its association with postural stability and fear of falling among Spanish postmenopausal women. *Menopause*. 2018;25(1):62-69. doi:10.1097/GME.0000000000000941

8. APPENDICES

8.1. Appendix I. Ethical Committee Approval

T.C. YEDİTEPE ÜNİVERSİTESİ

Sayı : 37068608-6100-15- 1951 **10/09/2020**
Konu: Klinik Araştırmalar
Etik Kurul Başvurusu hk.

İlgili Makama (İlkay Tuğçe Köse)

Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi Fizyoterapi ve Rehabilitasyon Bölümü Dr. Öğr. Üyesi Çiğdem Yazıcı Mutlu'nun sorumlu araştırmacı olduğu **"Sağlıklı Genç Yetişkinlerde Uyku Kalitesi ve Gündüz Uykululuğunun Postüral Kontrol Üzerine Etkileri"** isimli araştırma projesine ait Klinik Araştırmalar Etik Kurulu (KAEK) Başvuru Dosyası **(1943)** kayıtlı Numaralı KAEK Başvuru Dosyası ,Yeditepe Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından **09.09.2020** tarihli toplantıda incelenmiştir.

Kurul tarafından yapılan inceleme sonucu, yukarıdaki isim belirtilen çalışmanın yapılmasının etik ve bilimsel açıdan uygun olduğuna karar verilmiştir.

(KAEK Karar No: 1283)

Prof. Dr. Turgay Çelik

Yeditepe Üniversitesi
Klinik Araştırmalar Etik Kurul Başkanı

Yeditepe Üniversitesi 26 Ağustos Yerleşimi, İnönü Mahallesi Kayışdağı Caddesi 34755 Ataşehir / İstanbul
T. 0216 578 00 00 www.yeditepe.edu.tr F. 0216 578 02 99

8.2. Appendix II. Informed Consent

BİLGİLENDİRİLMİŞ GÖNÜLLÜ OLUR FORMU

Sayın katılımcı;

Davet edildiğiniz *"Sağlıklı Genç Yetişkinlerde Uyku Kalitesi ve Gündüz Uykululuğunun Postüral Kontrol Üzerine Etkileri"* isimli bu çalışma; Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Fizyoterapi ve Rehabilitasyon Bölümü tarafından yürütülmektedir ve yüksek lisans öğrencisi Fzt. İlkay Tuğçe KÖSE'nin uzmanlık tez çalışmasıdır.

Çalışmanın amacı sağlıklı genç yetişkinlerde gece uyku kalitesinin ve gündüz uykululuğunun postüral kontrol üzerindeki etkilerinin araştırılmasıdır. Vereceğiniz yanıtlar araştırmanın geçerliliği ve güvenilirliği açısından büyük bir önem arz etmektedir. Sizden beklenen, bütün soruları eksiksiz, kimsenin baskısı veya telkini altında olmadan, size en uygun gelen cevapları içtenlikle verecek şekilde cevaplamanızdır.

Çalışmaya katılım tamamen gönüllülük esasına dayanmaktadır. Çalışmaya katılmama veya katıldıktan sonra herhangi bir anda çalışmayı sonlandırma hakkına sahipsiniz. Çalışma sırasında verdiğiniz yanıtlar ve kişisel bilgiler tamamen bilimsel araştırma için kullanılacaktır.

Katılımcılardan; Demografik Bilgi Formu, Pittsburgh Uyku Kalitesi İndeksi, Epworth Uykululuk Ölçeği ve Stanford Uykululuk Ölçeğini cevaplamaları istenecektir. Denge ölçümü ise Prokin PK200 cihazı kullanılarak yapılacaktır.

Çalışma için sizden bir ücret talep edilmeyecek ve size herhangi bir ücret ödenmeyecektir. Çalışma sonunda size özel sonuçların sizinle paylaşılmasını istiyorsanız lütfen araştırmacıya iletiniz.

Katılımınız için teşekkürler.

Danışman: **Dr. Öğr. Üyesi Çiğdem YAZICI MUTLU** Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi Fizyoterapi ve Rehabilitasyon Bölümü	**Araştırmacı:** **Fzt. İlkay Tuğçe KÖSE** Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Fizyoterapi ve Rehabilitasyon Yüksek Lisans Programı

Onay Formu

Bilgilendirme formundaki tüm açıklamaları okudum. Bana, yukarıda konusu ve amacı belirtilen çalışma ile ilgili yazılı ve sözlü açıklama araştırmacı tarafından yapıldı.

Araştırmaya katılmaya gönüllü olduğumu, istediğim zaman gerekçeli veya gerekçesiz olarak araştırmadan ayrılabileceğimi biliyorum.

Söz konusu çalışmaya hiçbir baskı ve zorlama olmaksızın kendi rızamla katılmayı kabul ediyorum.

Gönüllünün

Adı Soyadı:

İmza:

Tlf:

Araştırmacının

Adı Soyadı:

İmza:

Tarih:

8.3. Appendix III. Demographic Information Form

Tarih:…../…../……

DEMOGRAFİK BİLGİ FORMU

Bu form size hakkınızda genel bilgiler edinmek ve çalışmaya dahil edilmenize engel bir durum olup olmadığını belirlemek amacıyla verilmiştir.

Lütfen bütün soruları cevaplayınız.

GENEL BİLGİLER

Adı-Soyadı:

Yaş:

Cinsiyet:

Boy (cm): Vücut Ağırlığı (kg):

Alt Ekstremitede Dominant Taraf: Sağ ( ) Sol ( )

1)Sigara kullanıyor musunuz?

( ) Hiç içmedim

( ) İçiyorum -Günde kaç adet sigara içiyorsunuz?_______________

( ) İçiyordum bıraktım -Ne zamandır sigara içmiyorsunuz? ________________

2)Alkol kullanıyor musunuz?

( ) Evet –Ne kadar sıklıkta alkol tüketiyorsunuz?_________________

( ) Hayır

3)Düzenli kullandığınız bir ilaç var mı?

( ) Evet -Evet ise nedir?___________________

( ) Hayır

4)Herhangi bir operasyon geçirdiniz mi?

( ) Evet ( ) Hayır

Evet, ise ne operasyonu olduğunu belirtiniz _________________

Operasyon hangi tarihte geçirildi?_________________

5)Kullandığınız yardımcı cihaz var mı? ( ) Yok

( ) Tabanlık

( ) Dizlik

( ) Gözlük/ Lens

( ) İşitme cihazı

( ) Yürümeye yardımcı cihaz

6)Herhangi bir sistemik (sürekli) hastalığınız var mı?

( ) Yok

( ) Vestibular (Denge ile ilgili) hastalıklar

( ) Kalp damar hastalıkları (kalp yetmezliği, ritim bozukluğu, tansiyon, kansızlık, kalp damar hastalıkları vb.)

( ) Solunum sistemi hastalıkları (Astım, Alerji, KOAH vb.)

( ) Kulak ile ilgili rahatsızlıklar (Duyma problemi vb.)

( ) Sinir sistemi hastalıları (Vertigo, epilepsi, nöropati, his kaybı vb.)

( ) Enfeksiyon hastalıları (Bademcik iltihabı, kulak iltihabı vb.)

( ) Hormonal rahatsızlıklar (Diyabet, guatr, insülin direnci vb.)

( ) Kas iskelet sistemi rahatsızlıkları (Kas, eklem, tendon hastalıkları, romatizmal hastalıklar vb.)

( ) Sindirim sistemi, metabolizma hastalıkları (Gastrit, ülser, bağırsak hastalıkları vb.)

( ) Görme bozukluğu

AKTİVİTE BİLGİLERİ

7)Spor yapıyor musunuz? Yapıyorsanız hangi sıklıkta spor yapıyorsunuz?

( ) Yapmıyorum (Cevabınız yapmıyorum ise 10. soruya geçiniz.)

( ) Haftada 1-2 kez

( ) Haftada 3-4 kez

( ) Her gün

( ) Ayda 3 günden az

Eğer egzersiz yapıyorsanız her egzersiziniz en az kaç dakika sürüyor?___________

8)Yapmayı tercih ettiğiniz spor nedir- nelerdir?

( ) Futbol ( ) Basketbol ( ) Voleybol ( ) Tenis ( ) Koşu ( ) Yüzme

Diğer________________

9)Spor yapanlar için, yaptığınız spor her seferinde kaç dakika sürüyor?

( ) 20 dakika veya daha az

( ) 21-30 dk.

( ) 31-50 dk.

( ) 50 dakikadan daha fazla

ALT EKSTREMİTE (KALÇA, DİZ, AYAK BİLEĞİ, AYAK) DEĞERLENDİRMESİ

10)Son altı ay içinde alt ekstremitenizden (kalça, diz, ayak bileği, ayak) sakatlandınız mı?

( )Hayır

( )Kalça ( )Diz ( )Ayak ( )Ayak bileği

11)Son altı ay içerisinde alt ekstremitenizden (kalça, diz, ayak bileği, ayak) operasyon geçirdiniz mi?

( )Hayır ( )Evet – Evet ise belirtiniz_________________________

12)Hiç ayak bileği burkulması yaşadınız mı?

( )Evet ( )Hayır (Cevabınız hayır ise 18.soruya geçiniz.)

13)Hangi ayak bileğinizi burktunuz?

( )Sağ ( )Sol

14)Burkulma ne kadar süre önce oldu?

( )Son 1-6 ay ( )Son 7-12 ay ( )Son 13-24 ay ( )24 aydan fazla

15)Aynı ayak bileğinizde tekrarlayan burkulma şikâyetiniz oldu mu?

( )Evet- Kaç defa oldu?_______________________________

( )Hayır

16)Burkulma şikâyetinizden sonra fizik tedavi gördünüz mü?

( )Evet ( )Hayır (Hayır ise 18.soruya geçiniz)

17)Fizik tedavi gördüğünüz tarih nedir______________________

18)Aşağıda belirtilen durumlardan sahip olduklarınızı işaretleyiniz

( ) Düz olmayan zeminde güvensiz basma hissi

( ) Sportif aktiviteler esnasında güvensiz basma hissi

( ) Ayak bileğinizde boşalma ya da dönme

( ) Ayak bileğinizde tekrarlayan ağrılı dönemler

( ) Yoğun aktivite sonrası tekrarlayan şişlik, kuvvetsizlik ve zayıflık hissi

( ) Hiçbiri

Teşekkür Ederim ☺

8.4. Appendix IV. Pittsburgh Sleep Quality Index

Tarih:…../……/……….

Pittsburgh Uyku Kalite İndeksi (PUKİ)

Pittsburgh Sleep Quality Index (PSQI)

Uyku kalitesi terimi kişinin gece ne kadar iyi uyuduğunu belirtir. PUKİ'nin size veriliş amacı sizin ne kadar kaliteli bir gece uykusu uyuduğunuzu belirlemektir; herhangi bir uyku problemine yönelik tanı koymaz.

Lütfen aşağıdaki soruları dürüst bir şekilde cevaplayınız.

Adı Soyadı:

1) Geçen ay geceleri genellikle ne zaman yattınız? ______________
2) Geçen ay geceleri uykuya dalmanız genellikle ne kadar zaman (dakika) aldı? ________
3) Geçen ay, sabahları genellikle ne zaman kalktınız? ______________
4) Geçen ay, geceleri kaç saat uyudunuz? (Bu süre yatakta geçirdiğiniz süreden farklı olabilir.)________
5) Geçen ay, aşağıdaki durumlarda belirtilen uyku problemlerini ne sıklıkla yaşadınız?

		Hiç	**Haftada 1 defadan az**	**Haftada 1-2 defa**	**Haftada 3 defa veya daha fazla**
a	30 dakika içinde uykuya dalamadınız	☐	☐	☐	☐
b	Gece yarısı veya sabah erkenden uyandınız	☐	☐	☐	☐
c	Tuvalete gittiniz	☐	☐	☐	☐
d	Rahat nefes alıp veremediniz	☐	☐	☐	☐
e	Aşırı derecede üşüdünüz	☐	☐	☐	☐
f	Aşırı derecede sıcaklık hissettiniz	☐	☐	☐	☐
g	Kötü rüyalar gördünüz	☐	☐	☐	☐
h	Ağrı duydunuz	☐	☐	☐	☐
İ	Öksürdünüz veya gürültülü bir şekilde horladınız	☐	☐	☐	☐
J	Diğer nedenler	☐	☐	☐	☐

6) Geçen ay, uyku kalitenizi bütünü ile nasıl değerlendirirsiniz?

☐ Çok iyi ☐ Oldukça iyi ☐ Oldukça kötü ☐ Çok kötü

7) Geçen ay, uyumanıza yardımcı olması için ne sıklıkta (reçeteli veya reçetesiz) uyku ilacı aldınız?

☐ Hiç ☐ Haftada 1 defadan az ☐ Haftada 1-2 defa ☐ Haftada 3 defa veya daha fazla

8) Geçen ay, araba sürerken, yemek yerken veya sosyal aktivite esnasında ne kadar sıklıkla uyanık kalmak için zorlandınız?

☐ Hiç ☐ Haftada 1 defadan az ☐ Haftada 1-2 defa ☐ Haftada 3 defa veya daha fazla

9) Geçen ay, bu durum işlerinizi yeteri kadar istekle yapmanızda ne derece problem oluşturdu?

☐Hiç problem oluşturmadı ☐ Bir dereceye kadar problem oluşturdu

☐ Yalnızca çok az bir problem oluşturdu ☐ Çok büyük bir problem oluşturdu

10) Bir yatak partneriniz veya oda arkadaşınız var mı?

(Bu soruyu "yok" olarak cevapladıysanız lütfen bir sonraki ölçeğe geçiniz.)

☐ Bir yatak partneri veya oda arkadaşı yok ☐ Partneri aynı odada fakat aynı yatakta değil

☐ Diğer odada bir partneri veya oda arkadaşı var ☐ Partner aynı yatakta

11) Eğer bir oda arkadaşı veya yatak partneriniz varsa son bir ayda ona aşağıdaki durumları ne sıklıkta yaşadığınızı sorun.

		Hiç	**Haftada 1 defadan az**	**Haftada 1-2 defa**	**Haftada 3 defa veya daha fazla**
a	Gürültülü horlama	☐	☐	☐	☐
b	Uykuda nefes alıp verme arasında uzun aralıklar	☐	☐	☐	☐
c	Uyurken bacakta seğirme veya sıçrama	☐	☐	☐	☐
d	Uyku esnasında uyumsuzluk veya şaşkınlık	☐	☐	☐	☐
e	Diğer huzursuzluklarınız	☐	☐	☐	☐

8.5. Appendix V. Epworth Sleepiness Scale

Tarih:…../……/……….

Epworth Uykululuk Ölçeği (EUÖ)

Epworth Sleepiness Scale (ESS)

Adı Soyadı:

Son zamanlarda, günlük yaşantınız içinde, aşağıda belirtilen durumlarda hangi sıklıkla uyuklarsınız? (Burada yorgun hissetmek değil, uyuklamak veya uyuya kalmak anlaşılmalıdır.)

Aşağıda verilenlerden birini son zamanlarda yapmamış olsanız bile, böyle bir durumun, sizi nasıl etkileyeceğini düşünmeye çalışarak cevap veriniz.

		Hiçbir zaman uyuklamam	**Nadiren uyuklarım**	**Zaman zaman uyuklarım**	**Büyük olasılıkla uyuklarım**
1	Oturmuş bir şeyler okurken	☐	☐	☐	☐
2	Televizyon seyrederken	☐	☐	☐	☐
3	Toplum içinde hareketsizce otururken (örneğin; herhangi bir toplantı veya tiyatro gibi yerlerde)	☐	☐	☐	☐
4	Ara vermeden en az bir saat süren araba yolculuğunda yolcu olarak bulunurken	☐	☐	☐	☐
5	Öğleden sonra koşular uygun olduğunda dinlenmek için uzanmışken	☐	☐	☐	☐
6	Birisiyle oturmuş konuşurken	☐	☐	☐	☐
7	Alkol almadığım bir öğle yemeğinden sonra sessizce otururken	☐	☐	☐	☐
8	İçinde olduğum araba, trafikte bir kaç dakika için durduğunda	☐	☐	☐	☐

8.6. Appendix VI. Stanford Sleepiness Scale

Tarih: …../……/……….

Stanford Uykululuk Ölçeği (SUÖ)

Stanford Sleepiness Scale (SSS)

Bu ölçek size şu anki uykululuk halinizi belirlemek için verilmiştir. Lütfen aşağıdaki durumlardan size en yakın olan birini işaretleyiniz.

Adı Soyadı:

Uykululuk Hali	Ölçek Derecesi
Aktif; canlı; uyanık	1
Maksimum değil ama yüksek düzeyde fonksiyonel; yapılan işe odaklanabilir	2
Uyanık durumda fakat relaks, yanıt veriyor ama tam tetikte değil	3
Bazen dalgın	4
Dalgın; uyanık kalmaya ilgisini kaybetmiş; hareketleri yavaşlamış	5
Belirgin uyku hali var; sürekli yatmayı tercih ediyor	6
Uyanık kalamıyor; kısa sürede uykuya geçiyor; hep rüyada gibi	7