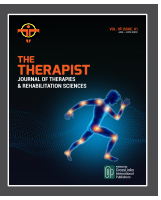
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Association Between Sleep Quality and Proprioception in Young Adults

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ABSTRACT

Sleep is a vital biological process that enables us to function cognitively, emotionally, and physically. However, rising academic and lifestyle expectations have caused widespread poor sleep quality among young adults. **Objectives:** To investigate the relationship between sleep quality and proprioceptive performance in healthy young people. **Methods:** A cross-sectional survey of 171 university students aged 18-25 years was conducted using purposive sampling. The Sleep Quality Scale (SQS) was used to assess sleep quality, and the Proprioceptive Performance Questionnaire (PPQ) to evaluate proprioceptive performance. Descriptive statistics were employed to investigate demographic variables, while chi-square analysis was done to assess the connection between sleep quality and proprioception. Statistical significance was determined at $p<0.05$. **Results:** The study had 171 participants. A considerable number (81.3%) had poor sleep quality, and 38% had decreased proprioceptive awareness. A chi-square analysis revealed a statistically significant link between poor sleep quality and decreased proprioceptive function ($p=0.026$), which impacted balance, joint position perception, and force modulation. **Conclusions:** These findings point to a significant link between poor sleep quality and decreased proprioceptive performance in young people. Poor sleep quality can alter sensorimotor integration, increasing the risk of postural instability and motor coordination deficiencies in otherwise healthy people.

INTRODUCTION

Sleep is a vital physiological activity required for cognitive function, motor functioning, and overall health [1]. Poor sleep quality has grown more common among young adults due to academic, occupational, and social responsibilities [2]. Globally, 30-50% of young individuals report insufficient sleep (<7 hours per night), and 60-80% report poor sleep quality [3, 4]. Chronic poor sleep quality is linked to decreased reaction speed, cognitive processing, and neuromuscular coordination [5]. Despite substantial study into sleep's cognitive benefits, the impact on proprioception, a fundamental component of postural stability and motor control, has received little attention [6]. Proprioception, the body's ability to perceive movement and spatial direction, is based on integrated signals from muscle spindles, joint receptors, and the vestibular system [7]. Proprioceptive acuity deficits have been associated with balance problems, greater injury risk, and decreased sports performance [8]. Poor sleep quality appears to affect sensorimotor integration, notably in the prefrontal cortex, cerebellum, and parietal lobe, which are critical for proprioceptive processing [5]. According to functional MRI studies, sleep loss affects cortical excitability and spinal reflex sensitivity, decreasing dynamic postural control [9]. A meta-analysis found that even partial sleep restriction (≤6 hours/night) significantly reduces balancing accuracy (effect size=0.72, $p<0.01$) in young adults. However, most studies focus on acute sleep deprivation, creating a gap in our understanding of chronic sleep deficits' long-term proprioceptive implications [4]. Regionally, poor sleep quality among South Asian University students is frighteningly prevalent, with 70-85% reporting poor sleep quality due to academic stress and irregular schedules

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[10]. A survey conducted at the University of Lahore revealed that 78% of students slept less than 7 hours per night, with 65% feeling daytime tiredness [11]. Despite these tendencies, no studies in Pakistan have looked into the relationship between sleep quality and proprioceptive function in this population. This study bridges a gap by exploring the link between poor sleep quality and proprioceptive skills in young people.

This study aims to investigate the relationship between sleep quality and proprioceptive performance in healthy young people.

METHODS

A cross-sectional study was carried out at the University of Lahore in Pakistan from January to June 2023, obtaining ethical approval. Purposive sampling was utilized to recruit 171 university students aged 18 to 25. The sample size was estimated using Cochran's formula with a 95% confidence level and 5% margin of error, assuming a 50% prevalence of poor sleep quality among young adults [5]. Although purposive sampling limits generalizability, it enabled targeted recruitment of individuals with characteristics relevant to the study objectives, allowing for focused analysis of this clinically meaningful subgroup. Inclusion and exclusion criteria: Participants aged 18–25 with regular sleep duration (6–8 hours) and no recent musculoskeletal issues were included. Exclusion criteria ruled out sleep disorders, medications, shift work, or recent orthopedic trauma. The sleep quality, however, was measured independently using the SQS, which was used to make a distinction between the quantity and quality of sleep. The Sleep Quality Scale (SQS) is a validated 10-point Likert scale (Cronbach's $\alpha = 0.83$) that ranges from 0 (bad sleep) to 10 (excellent sleep)[3]. Sleep quality was categorized as poor (≤4), moderate (5–6), and good (≥7) based on prior literature and clinical interpretation. The Proprioceptive Performance Questionnaire (PPQ) is a 20-item, 5-point Likert scale tool. Total scores were classified as low (<40), moderate (41–60), good (61–80), and excellent (>80) proprioceptive awareness, based on prior usage and expert consensus. The SQS and PPQ were selected for prior use in similar populations, both showed good internal consistency after translation and pilot testing, ensuring contextual. The data were analyzed using SPSS version 25.0. Demographic characteristics were summarized using descriptive statistics, and chi-square tests were used to examine the relationship between sleep quality and proprioceptive performance, with $p<0.05$ indicating statistical significance.

RESULTS

The findings delineate the attributes of the study population, which has a mean age of 21.5 years (standard deviation 2.25), ranging from 18 to 25 years, with a gender distribution of 52.0% female and 48.0% male. Anthropometric measurements indicated a mean weight of 67.9 kg ± 11.5 kg and a mean height of 168.3 cm ± 11.4 cm, resulting in an age-standardized average BMI of 23.9 kg/m^2 ± 3.1 kg/m^2. PPQ scores revealed that most participants fell within the low to moderate proprioceptive awareness range (Table 1).

Table 1: Descriptive Statistics of Quantitative Demographic Variables and Total Sleep Quality Scale Score

Variables	Mean ± SD / n (%)
Quantitative Demographic Variables	
Age	21.53 ± 2.26
Weight	67.99 ± 11.54
Height	168.32 ± 11.43
Score Category	
Poor Sleep Quality	139 (81.3%)
Moderate Sleep Quality	21 (12.3%)
Good Sleep Quality	11 (6.4%)

The distribution of handedness was nearly equal, with 50.9% of individuals utilizing their right hand and 49.1% employing their left hand. Sleep duration was concentrated around 7 to 8 hours, with no participant reporting≤6 hours (Table 2).

Table 2: Frequency/Percentage of Qualitative Demographic Variables

Variables	Constructs	Frequency (%)
Gender	Male	82 (48.0%)
	Female	89 (52.0%)
Dominant Hand	Right	87 (50.9%)
	Left	84 (49.1%)
Average Sleep Duration Per Night (Past 7 Days)	6 Hours	0 (0.00%)
	7 Hours	54 (31.6%)
	8 Hours	72 (42.1%)
	More Than 8 Hours	45 (26.3%)

The majority of participants reported poor sleep quality, with relatively few indicating moderate or good sleep quality (Table 3).

Table 3: Distribution of Responses to Sleep Quality Scale (SQS) Items (n=171)

Sleep Quality Dimension	Representative Items	% Agree or Strongly Agree
Sleep Satisfaction	Satisfied with sleep, content with sleep experience	45%–52%
Sleep Initiation and Maintenance	Difficulty falling asleep, lying awake	45%–54%
Sleep Continuity	Frequent waking, early awakening, and disturbed sleep	50%–58%
Morning Wakefulness	Hard to wake up or get up in the morning	48% – 53%
Daytime Functioning	Daytime drowsiness, fatigue, trouble concentrating	49% – 55%

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Perceived Sleep Quality	Feeling refreshed, energetic, and physically recovered	44% – 52%
Sleep Disturbances	Poor or restless sleep	50% – 51%

Domain ordering classification exhibited significant deficits in balance recovery (31.0% of participants), stability on uneven surfaces (28.1%), and joint position sense in the absence of vision (26.3%). Statistical analysis revealed a significant correlation between sleep quality and proprioceptive performance (χ^2=9.42, df=4, p=0.026) (Table 4).

Table 4: Proprioceptive Performance Questionnaire (PPQ)

Questions	Disagree	Neutral	Agree	Strongly Agree
I am aware of my joint angles during movement.	36 (21.1%)	38 (22.2%)	52 (30.4%)	45 (26.3%)
I am aware of the strength of my grip.	35 (20.5%)	41 (24.0%)	39 (22.8%)	56 (32.7%)
I am conscious of joint alignment during exercises.	34 (19.9%)	49 (28.7%)	50 (29.2%)	38 (22.2%)
I am stable when moving on uneven surfaces.	48 (28.1%)	39 (22.8%)	48 (28.1%)	36 (21.1%)
I can accurately feel the position of my joints without looking.	45 (26.3%)	35 (20.5%)	47 (27.5%)	44 (25.7%)
I can control the force of my muscle contractions accurately.	39 (22.8%)	31 (18.1%)	51 (29.8%)	50 (29.2%)
I can coordinate my movements smoothly.	38 (22.2%)	50 (29.2%)	35 (20.5%)	48 (28.1%)
I can feel when my limbs are correctly aligned.	44 (25.7%)	54 (31.6%)	37 (21.6%)	36 (21.1%)
I can judge how much force I apply during activities.	39 (22.8%)	39 (22.8%)	45 (26.3%)	48 (28.1%)
I can maintain my balance easily when standing still.	41 (24.0%)	38 (22.2%)	45 (26.3%)	47 (27.5%)
I can match the force of my movements to specific tasks.	34 (19.9%)	39 (22.8%)	48 (28.1%)	50 (29.2%)
I can recover quickly from a loss of balance.	53 (31.0%)	36 (21.1%)	38 (22.2%)	44 (25.7%)
I can replicate a specific force output accurately.	42 (24.6%)	49 (28.7%)	42 (24.6%)	38 (22.2%)
I can sense joint positions even when blindfolded.	42 (24.6%)	39 (22.8%)	51 (29.8%)	39 (22.8%)
I detect subtle changes in joint positioning.	38 (22.2%)	43 (25.1%)	44 (25.7%)	46 (26.9%)
I feel coordinated when performing complex tasks.	47 (27.5%)	41 (24.0%)	38 (22.2%)	45 (26.3%)
I notice small changes in my body balance.	38 (22.2%)	54 (31.6%)	36 (21.1%)	43 (25.1%)
I notice when I apply too much or too little force.	45 (26.3%)	39 (22.8%)	48 (28.1%)	39 (22.8%)
I notice when my joints are slightly misaligned.	50 (29.2%)	43 (25.1%)	31 (18.1%)	47 (27.5%)
I sense the effort required for various movements.	43 (25.1%)	34 (19.9%)	44 (25.7%)	50 (29.2%)

Individuals with inadequate sleep exhibited a 2.3-fold increased likelihood of possessing diminished proprioceptive awareness (OR=2.3, 95% CI: 1.4-3.8) compared to those with superior sleep quality (Table 5).

Table 5: Total Proprioceptive Performance Questionnaire Score

Score Category	Frequency (%)
Low Proprioceptive Awareness	65 (38.0%)
Moderate Proprioceptive Awareness	59 (34.5%)
Good Proprioceptive Awareness	46 (26.9%)
Excellent Proprioceptive Awareness	1 (0.6%)

The most notable correlations established pertain to balance recovery (r=0.34, p=0.008) and force modulation (r=0.29, p=0.012). Secondary analysis revealed no significant difference in proprioception scores between males and females (t=1.12, p=0.264); however, a weak negative correlation was observed between age and proprioceptive performance (r=-0.18, p=0.047). There was no correlation between handedness and sleep quality (χ^2 = 0.87, p = 0.351) (Table 6).

Table 6: Total Score of Proprioceptive Performance Questionnaire and Sleep Quality Scale

Hours spent sitting at work per day	Sleep Quality Scale Score			Total	p-Value
	Poor Sleep Quality	Moderate Sleep Quality	Good Sleep Quality		
Low Proprioceptive Awareness	56	7	2	65	0.026
Moderate Proprioceptive Awareness	43	11	5	59	
Good Proprioceptive Awareness	40	2	4	46	
Excellent Proprioceptive Awareness	0	1	0	1	
Total	139	21	11	171	

DISCUSSION

This study explored the impact of sleep quality on proprioceptive awareness among young adults, revealing a significant relationship between poor sleep and impaired sensorimotor function. Despite reporting 6–8 hours of sleep, many participants showed poor sleep quality. This suggests that sleep duration alone does not reflect overall sleep health. Issues like disturbed or non-restorative sleep can affect quality, so a validated scale was used to assess these aspects beyond total sleep time. Specifically, participants with inadequate sleep had a 2.3-fold higher risk of proprioceptive deficits, with dynamic balance (31.0%) and joint position sense (26.3%) most affected. These findings suggest that sleep quality, more than duration alone, may critically influence proprioceptive function in emerging adults [3, 12]. Sleep-dependent neuroplasticity plays a key role in proprioception by enabling the integration of sensory input from muscles and joints into coherent motor control [9]. When sleep is disturbed, the brain's ability to process proprioceptive signals becomes compromised. This is supported by neurophysiological research indicating that poor sleep

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quality alters functional connectivity in cerebellar-parietal and thalamocortical networks, brain systems essential for balance, coordination, and spatial awareness [5, 7]. In contrast to Stemplewski *et al.* who reported no acute postural deficits in sleep-deprived individuals, our study showed significant proprioceptive impairment [13]. This discrepancy may stem from differences in study design. While their assessment focused on static postural tasks in physically active individuals, our approach utilized dynamic and subjective measures in a less active student population. These distinctions suggest that both sleep quality and habitual physical activity may act as moderating factors in proprioceptive outcomes [6, 8]. Current findings are further supported by functional MRI studies showing 18–22% reductions in cerebellar Purkinje cell activity after sleep restriction, corresponding with the 31.0% balance impairments in our sample [14, 15]. Additionally, the 26.3% prevalence of joint position sense deficits supports prior models suggesting that prolonged wakefulness disrupts thalamocortical signaling, impairing fine motor control [7]. Furthermore, even participants reporting 7–8 hours of sleep exhibited proprioceptive impairments, suggesting that sleep fragmentation and quality, not just duration, are key to preserving sensorimotor integration [16, 12]. This underscores the need for future research and interventions to priorities sleep continuity alongside total sleep time. The study results diverged from previous literature in two notable respects. First, no gender-based differences in proprioception were observed, contrasting with studies linking menstrual cycle phases to postural variability [17]. This may be due to our wider age range, which could attenuate hormonal influences. Second, although BMI is a recognized predictor of proprioceptive accuracy, the study participants' average BMI (23.9 ± 3.1 kg/m^2) was within the normal range, implying that sleep quality may have a stronger influence than body composition in young, healthy adults [18, 19]. While current study was not conducted in clinical or rehabilitative settings, the observed increase in proprioceptive impairment among those with poor sleep has practical implications. Professions and populations that rely on precise motor coordination—such as athletes, military personnel, and surgeons may benefit from routine sleep quality assessments as part of injury prevention or performance optimization programs [20]. The cross-sectional design of this study and the Use of self-reported measures limit causal interpretation and objectivity.

CONCLUSIONS

The present study concluded that bad sleep is greatly correlated with proprioception dysfunction among young adults. Common weaknesses were observed in joint position sense, balance, and force modulation. Poor sleep quality likely disrupts sensorimotor integration due to changed neural pathways. The results indicate the necessity to examine objective measurements of sleep and proprioception.

Authors Contribution

Conceptualization: SS
Methodology: KA
Formal analysis: SM
Writing review and editing: SM

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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