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Influence of Different Positions on Results of Proprioception Testing in Young Adults

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ABSTRACT

Background: Proprioception is the body's ability to sense joint position without visual cues, essential for balance, posture, and movement. Research on knee proprioception often uses limited positions, while functional, weight-bearing positions remain underexplored.

Aim: To examine how different body positions—weight-bearing and non-weight-bearing—affect knee joint proprioception in young adults.

Methods: Forty-four healthy participants (18–30 years) with normal BMI were assessed using a mobile clinometer gyroscope in four positions: high sitting, supine leg press, standing partial squat, and supine hip-knee flexion in air. Participants replicated a self-selected knee angle without visual input. The absolute error between target and reproduced angles measured joint position sense.

Results: Mean joint position errors varied across positions, with the least error in the standing squat. However, repeated measures ANOVA showed no statistically significant differences ($p > 0.05$), including between the two supine positions. Although the standing squat showed the smallest error, this difference was not statistically significant.

Conclusion: While the results were not statistically significant, the standing squat position showed the smallest error suggesting better proprioceptive accuracy. Position-specific assessments may help identify proprioceptive deficits in clinical settings.

KEYWORDS

Proprioception, Knee Joint p, Body Position, Joint Position Sense

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Introduction

Proprioception refers to the body's ability to sense joint position without visual cues. It is crucial for balance, coordination and postural control (1). It allows individuals to perform daily activities such as standing or walking without constantly needing to check body segments. Impaired joint position sense can lead to poor postural control, reduced stability, and increased risk of joint problems.Conditions like stroke, Parkinson's disease, multiple sclerosis, and joint instability can compromise proprioception, increasing the risk of falls and instability (2).

Proprioception involves joint position sense (JPS) and kinesthesia. JPS refers to awareness of joint position at rest while kinesthesia refers to joint movement (3). Proprioceptors in the muscles, tendons, and joints relay sensory information back to the brain, prompting the brain to adjust posture and movement (4). Muscle spindles, in particular, are important for detecting joint angle (5). Proprioception differs depending on posture, so it is important to test awareness of joint position in several different postures (6). Evidence of forward reaching in a modified sitting position improved muscle activation in the paretic lower limb of individuals in the early sub-acute phase of stroke, signalling that posture can influence neuromuscular and proprioceptive responses, even in clinical populations (7). Body posture has a large impact on proprioception. Research has indicated that joint position sense is more reliable in weight-bearing (WB) conditions as compared to non-weight-bearing (NWB) conditions because muscle activation and compression at the joint provide additional sensory information. However, NWB posture tends to provide the least accurate awareness of joint position due to reduced sensory feedback (8). To understand proprioception better, joint position awareness should be studied in different positions especially during rehabilitation (9).

Additionally, physical activity and body composition have been associated with balance and stability. Individuals with higher levels of physical performance show better control in activities requiring joint awareness, which emphasizes the functional role of proprioception (10), (11).

Testing the joint position sense differs according to the particular test method being used. Two common methods involve open kinetic chain (OKC) and closed kinetic chain (CKC) testing. The lack of established standardization for test protocols has led to widely different results among studies (12). Furthermore, test results can be impacted by muscle activation, joint angle, and muscle or joint fatigue, highlighting the importance of testing a variety of positions (13). It is critical to examine the proprioception in a functional position rather than a fixed position for rehabilitative measures and to prevent injury. Testing proprioception in different positions helps identify any specific difficulties related to that posture (14). Proprioception is influenced by different factors such as muscle activity, loading of the joint, and the position of the body. Testing proprioception across multiple positions is imperative to gaining an accurate assessment when establishing and treating proprioception deficits (16).

Considering recent research highlighting the essential role of rehabilitation in functional recovery there is a growing emphasis on testing strategies that mimic real life movement which can better inform therapeutic approaches (16).

Since body composition influences balance and quality of movement is often enhanced by consistent physical engagement, understanding proprioceptive responses in varied postures is vital for improving overall motor capacity (17, 18). Although the majority of studies compare WB and NWB conditions, only a handful examine how specific postures can affect joint position sense (19).

The results could lead to the understanding of how postures can impact evaluation test protocol decisions as well as rehabilitation strategies related to joint stability and injury prevention contributing to good health and well-being (20).

This study aims to examine how different positions impact proprioception in young adults and to identify which posture provides the most accurate feedback about joint position.

Methodology

Studydesign

This Observational study was conducted in the Physiotherapy Outpatient Department (OPD) at Sri Ramachandra Institute of Higher Education and Research (SRIHER). This study was approved by the Institutional Ethics Committee for Student's Projects (Ref. No: CSP-III/25/JAN/15/26). The purpose and procedure of the study were explained to the participants, and signatures on the informed consent forms were obtained from each of them.

Sample Size

A total of 44 participants of both genders were included in the study. The required sample size was calculated a priori using repeated measures ANOVA ($\alpha = 0.05$, statistical power = 0.80) and an effect size of 0.55.

Participants

A total of 44 participants were screened for eligibility. This study included young adults aged between 18 to 30 years with a normal Body Mass Index (BMI) ranging from 18.5 to 24.9, in order to eliminate the potential influence of excess body weight on proprioceptive performance. Participants were excluded if they had any neurological disorders, chronic musculoskeletal conditions, or a history of significant lower limb injuries. Additional exclusion criteria included individuals currently taking medications known to affect proprioception and pregnant women. After screening, 44 participants met the eligibility criteria and were included in the study. The purpose and procedure of the study were explained to all participants, and written informed consent was obtained prior to their participation.

Procedure

According to eligibility requirements, participants were selected from the Department of Physiotherapy. Informed consent was obtained, and the study procedure was explained. Participants had five minutes to familiarize themselves with the procedure prior to testing. The researchers used a clinometer gyroscope to measure the angle and assess knee joint proprioception in four different positions. The smartphone clinometer gyroscope was secured on the lateral aspect of the participant's leg, approximately 2 to 3 cm below the fibular head, using a Velcro strap. Participants in the first trial shifted their knee to a self-selected knee flexion angle within a pain-free range. This angle was noted. Without any visual cues, they tried to match the same angle in the following two trials. The difference between the original and replicated angles was calculated. To reduce visual cues, participants kept their eyes closed during the testing. No feedback was given between trials. The tests were performed on the dominant leg, ensuring consistency across all trials for each participant.

Testing Positions

1. High Sitting (Non-Weight Bearing, Open Kinematic): The subject sat with their legs hanging loosely on a raised surface. The participant selected a self-selected knee flexion angle within a pain-free range. This angle was noted. They then tried to repeat the same angle in the following two trials, and the replication accuracy was noted.

2. Supine Lying Leg Press (Closed Kinematic, Non-Weight-Bearing): The participant lay on their back on a platform with one leg lifted. They selected a self-selected knee flexion angle within a pain-free range. This angle was noted. They then tried to replicate the same angle in the following two trials, and the replication accuracy was recorded.

3. Standing Partial Squat (Closed Kinematic and Weight-Bearing): The participant stood with their feet apart. They performed a comfortable squat to select a self-selected knee flexion angle within a pain-free range, which was recorded. In the following two trials, they tried to replicate the same angle, and the repetition accuracy was recorded.

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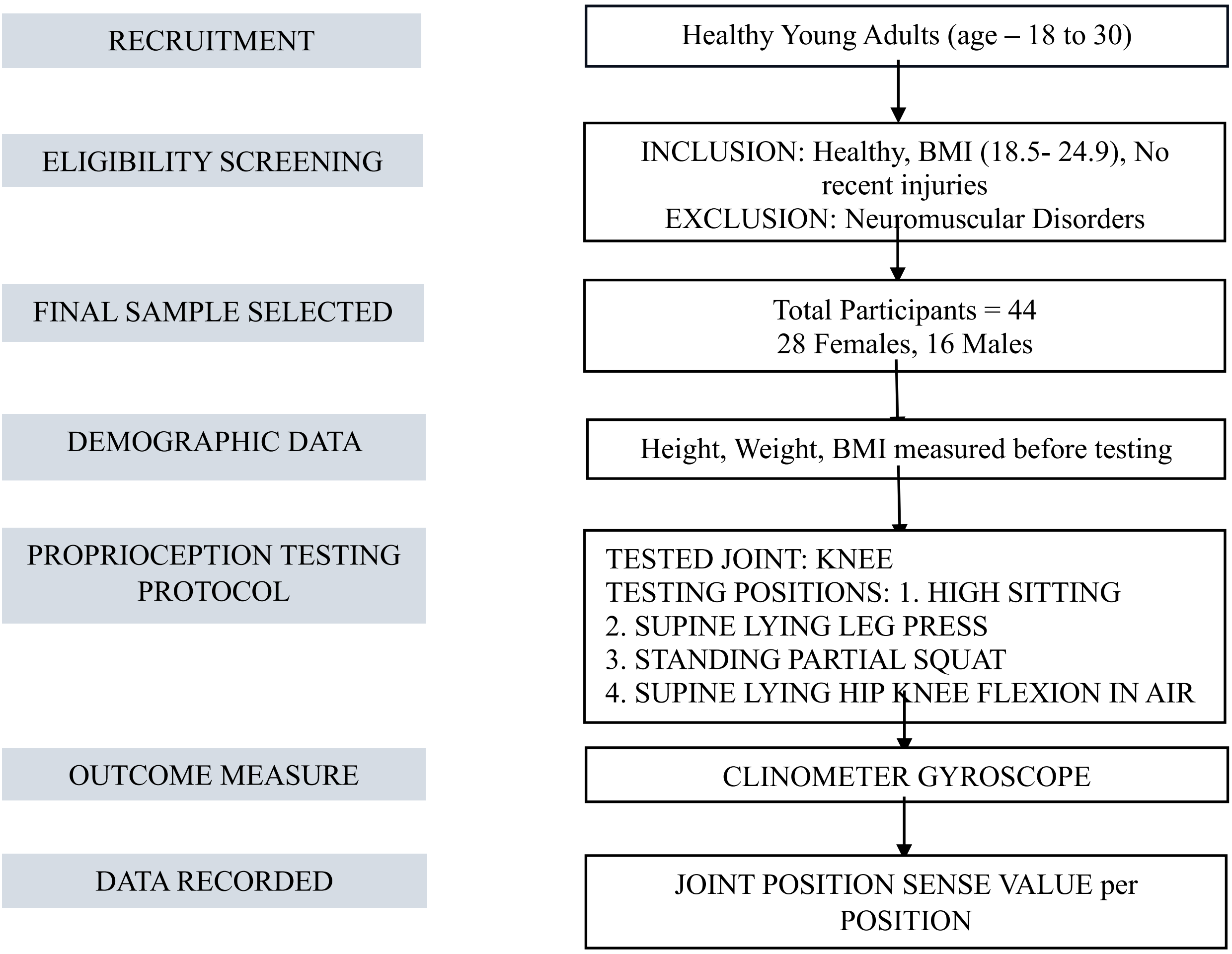
4. Supine Hip-Knee Flexion in Air (Open Kinematic, Non-Weight Bearing): The participant lay on their back and raised one leg, bent the knee to a self-selected knee flexion angle within a pain-free range. This angle was recorded. In the next two trials, they attempted to repeat the same angle, and their replication accuracy was recorded. Each position was assessed three times: once to set the angle and twice to measure how accurately participants replicated the same angle.

FIGURE 1 STROBE FLOW CHART



Statistical analysis

All statistical analyses were carried out using JASP Version 0.19.3. Descriptive statistics were used to calculate the mean and standard deviation of proprioception values across the four testing positions. A one-way repeated measures ANOVA was used to assess significant differences in proprioception between positions. Post hoc pairwise comparisons with Bonferroni correction were performed to identify specific positional differences. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1. Demographic Data

Variables	Value
Age (mean yrs, SD)	22.77±1.96
Gender F/M	28F/16M

Figure 2: Gender distribution of participants (28 females and 16 males)

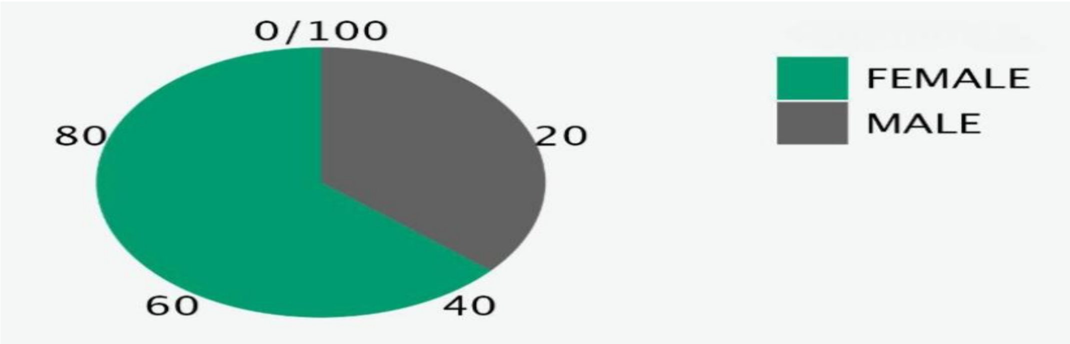


Figure 2 illustrates the gender distribution of the study participants, which included 28 females and 16 males.

Table 2. Repeated Measures of ANOVA for Proprioception Testing in Different Positions

Position	Mean	Standard Deviation	F - value	p - value
High sitting	42.89	8.60	6.253	0.003
Supine lying leg press	83.81	4.32	3.898	0.024
Standing partial squat	35.94	6.44	0.834	0.438
Supine lying hip knee flexion in air	84.02	3.99	0.292	0.747

Table 2 shows that proprioception values differed significantly in the high sitting and supine lying leg press positions (p-values < 0.05).No significant differences were found in the standing partial squat and supine lying hip knee flexion in air positions, indicating that these positions had less influence on proprioception accuracy.While the standing squat showed the smallest error in joint position sense, this difference was not statistically significant (p = 0.438).

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Table 3. Post hoc comparisons of proprioception values across all testing positions

Comparison	Mean difference	p	Cohen's d
High sitting – Supine lying leg press	-40.92	<.001	-6.60
High sitting – Standing partial squat	6.95	.002	1.12
High sitting – Supine lying hip knee flexion in air	-41.14	<.001	-6.64
Supine lying leg press – Standing partial squat	47.86	<.001	7.72
Supine lying leg press – Supine lying hip knee flexion in air	-0.22	1.000	-0.035
Standing partial squat – Supine lying hip knee flexion in air	-48.08	<.001	-7.76

Table 3 shows that the post hoc analysis revealed significant differences in proprioception between most of the testing positions.Large differences were found especially between high sitting and both supine lying positions, as well as between supine lying leg press and standing partial squat. Only the comparison between supine lying leg press and supine lying hip knee flexion in air was not significant, suggesting similar proprioception accuracy in those two positions.

Figure 3: Proprioception Testing in Different Positions

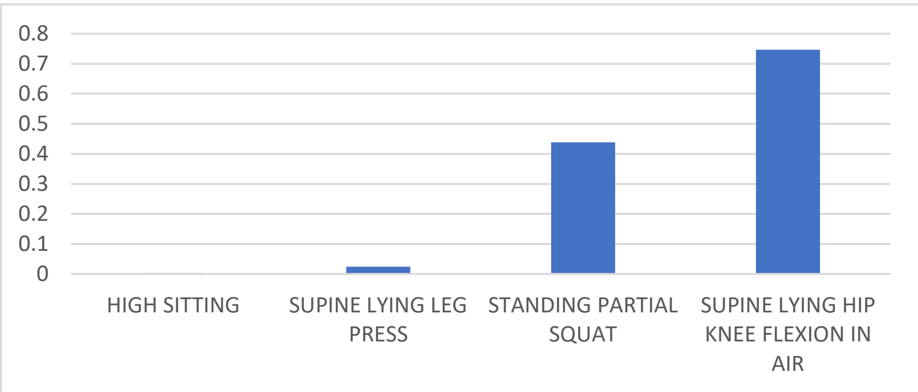

Figure 3 illustrates the different positions used for proprioception testing

Discussion

This study demonstrated that proprioception differs based on the tested position, supporting the conclusion that joint position sense is a flexible ability that depends on mechanical factors.

Thus, the present observations are in agreement with previous research by Kramer et al., and Borsa et al., who found that altering posture affected neuromuscular feedback and that this resulted in some measurable difference in joint position sense during testing [21], [22]. In this study, weight bearing positions produced better proprioceptive outcomes than non-weight bearing positions. These findings are in accordance with previous work from Drouin et al., Bullock-Saxton et al., and Lokhande et al., who all reported findings that showed joint position sense is better when tested under load bearing conditions [13], [14], [23]. The improved accuracy in the weight bearing positions is likely due to the increased sensory feedback from either joint compression or co-contraction of the muscle during such activities, potentially accounting for some of the findings in this study's weight bearing positions. While the standing squat showed the smallest mean error in joint position sense, the difference was not statistically significant and therefore should be interpreted with caution.

Given the observations of this study, it is clear that task-relevant testing, where the tested positions mimic a functional activity in daily life, obtained improved results than non-functional testing. This pattern is supported by Kiefer et al. and Olsson et al., who both indicated that the outcomes of the proprioceptive tests were better for the positions that were more functional [24], [25].

The study also revealed the task dependent nature of proprioception with differences in joint position sense in relation to changing body orientation. Similar to the study by Lönn et al., the findings again show that proprioceptive accuracy changes with body positioning which further supports use of multi positional testing to avoid missing deficits that could be present in certain positions [26]. The active repositioning tasks used in this study also afforded the opportunity to obtain reliable results, which was again consistent with the earlier findings of Andersen et al. and Clark et al. that suggested greater reliability for active compared to passive proprioceptive tests [12], [27].

Supporting this line of research, Herrington et al. described how voluntary movement enhances proprioceptive pathways, increasing the likelihood of accurate self-perception of joint position, which is a finding that was also observed in the current study [19]. In this study, proprioceptive performance increased in an active position of stability or weight bearing as muscular engagement increased. Stillman and Ghiasi et al. have noted that increased muscle activation leads to more sensory feedback from joint receptors and muscle spindles, which improves reliance on joint position sense [8], [28]. This study examined proprioception under both static and semi-dynamic conditions, which is consistent with the recommendations of Arumugam et al. and Lee and Lim, so that proprioceptive abilities are assessed to more accurately reflect the nature of real-life motor demands [6], [9]. Both of the studies emphasized that tests completed only in static positions do not represent the proprioceptive system demands necessary for functional movements. This limitation was addressed in the current study through the inclusion of more postures like partial squats and leg press.Testing positions forthis study were constructed to replicate aspects offunctional activities, anditwasfeltthatthisapproach more realistically representedproprioceptive abilities inthe context ofreal-life situations.

This study revealed that joint angle and limb position affected proprioceptive accuracy, with observed differences at different angles in joint position sense. Like Han et al. and Cho et al., we believe that joint angle affects proprioceptive accuracy by its own mechanical and neuromuscular influences, which is supportive of our testing multiple angles in this study [2], [20]. We took into consideration the value of context-specific proprioceptive testing; this is particularly true in rehabilitation. It was suggested by Taylor et al. and Kwon et al. that assessments should reflect the positions individuals will use and the movements individuals will perform in the functional activity after rehabilitation; in this study, we followed this suggestion by testing proprioception in positions similar to that of everyday activities [15], [29]. Physical attributes affected proprioceptive performance in this study, as there were differences between participants' body attributes in the testing positions.This finding also aligns with Numanoglu et al., who had previously also found that proprioception was affected by body composition, with higher body fat having an impact on increased errors during weight-bearing tasks [30].It is essential to measure proprioception in different functional positions because it not only helps monitor rehabilitation progress but also prevents injury. Previous studies have emphasized that proprioceptive training in patients with knee osteoarthritis led to increased joint stability and function[31]. Riva et al. also highlighted the role of proprioception to enhance sensorimotor control and maybe decrease injury risk in athletes[32].

Limitation

The lack of a clinical comparison group and the absence of assessment of limb dominance or participants' physical activity levels limit the generalizability of the findings.

Conclusion

This research highlights that knee proprioception varied across different positions, with significant differences found in the leg press and high sitting positions.No significant differences were observed in the standing partial squat and supine hip-knee flexion in air positions. This indicates that proprioception is affected by biomechanical and positional characteristics. The mobile clinometer gyroscope was shown to be a reliable and useful tool to assess joint position sense. Position-specific assessment is an important factor in identifying proprioceptive deficits as well as in planning rehabilitation. The study illustrated the clinical value of mobile technology and supported a position specific approach to proprioceptive assessment.

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