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Association between sleep quality and neuromuscular performance in recreational athletes

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Abstract
Sleep plays a critical role in athletic recovery and performance, yet its impact on neuromuscular function in recreational athletes remains understudied. This cross-sectional study investigated the relationship between sleep quality and upper-body stability performance using the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) and the Mirani's Assessment for Sleep Quality, Alertness & Functioning Impact in Sports Scale (MASQAFIS). A total of 244 recreational athletes (116 males, 128 females) were assessed for sleep quality, real-time sleepiness, and CKCUEST performance. Statistical analysis using Spearman's rank correlation revealed no significant association between sleep quality and neuromuscular performance ($\rho = 0.042$, $p = 0.514$). Secondary analyses indicated that males outperformed females in CKCUEST scores (22.03 ± 5.42 vs. 19.31 ± 3.14 touches), while females reported higher real-time sleepiness (2.77 ± 1.90 vs. 2.31 ± 1.77). These findings contrast with prior research on elite athletes, suggesting that recreational athletes may possess compensatory mechanisms that mitigate sleep-related performance declines. Additionally, the task-specific nature of the CKCUEST—emphasizing endurance over explosive power—may explain its resilience to sleep variations. Limitations include reliance on self-reported sleep data and a cross-sectional design. Future studies should incorporate objective sleep monitoring (e.g., actigraphy) and longitudinal assessments to better understand these relationships. The results highlight the need for tailored sleep interventions in recreational sports, particularly considering gender differences in sleep perception and performance.

Keywords: Sleep quality, neuromuscular performance, recreational athletes, CKCUEST, gender differences

Introduction

Sleep is a fundamental physiological process that plays a critical role in physical recovery, cognitive function, and overall athletic performance [1]. For athletes, sleep quality is particularly important as it influences neuromuscular coordination, reaction time, muscle recovery, and injury risk [2]. Despite its significance, sleep is often neglected, especially among recreational athletes who may prioritize training, academics, or work over adequate rest [3]. Poor sleep quality has been associated with decreased neuromuscular performance, slower reaction times, and increased susceptibility to injuries [4]. However, most research on sleep and athletic performance has focused on elite or professional athletes, leaving a gap in understanding how sleep affects recreational athletes [5].

Neuromuscular performance, which encompasses strength, coordination, endurance, and stability, is essential for athletic success [6]. The Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) is a validated measure of upper-body neuromuscular function, assessing stability and endurance in a functional, sport-specific manner [7]. Given that sleep deprivation and poor sleep quality impair motor control and reaction time [8]. It is plausible that recreational athletes with suboptimal sleep may exhibit diminished performance in tests like the CKCUEST.

Existing literature suggests that sleep disturbances negatively impact athletic performance, but few studies have specifically examined the relationship between sleep quality and neuromuscular function in recreational athletes [9]. Recreational athletes, who constitute a large segment of the physically active population, often face unique challenges such as irregular training schedules, academic or occupational stress, and inconsistent sleep patterns [3]. Understanding how sleep quality influences their neuromuscular performance could provide valuable insights for injury prevention and performance optimization.

This study aims to investigate the association between sleep quality and neuromuscular performance in recreational athletes using the CKCUEST and a validated sleep quality questionnaire. By addressing this gap, the findings may contribute to evidence-based recommendations for sleep hygiene and performance enhancement strategies in non-elite athletes.

Sleep is a vital component of athletic recovery and performance. It facilitates muscle repair, memory consolidation, and hormonal regulation [10]. Studies have shown that sleep deprivation leads to decreased reaction time, impaired judgment, and reduced endurance1 [1, 12]. Athletes who obtain insufficient or poor-quality sleep are at higher risk of injuries and prolonged recovery periods [13].

The relationship between sleep and neuromuscular function is particularly relevant because motor skills, balance, and coordination are highly dependent on neural efficiency [14]. Sleep loss disrupts proprioceptive control and increases postural instability, which may compromise performance in sports requiring precise movements [14]. Additionally, sleep deprivation alters cortisol and growth hormone levels, further impairing muscle recovery and adaptation [8].

In a view of sleep, unlike professional athletes, recreational athletes often lack structured recovery protocols and may underestimate the importance of sleep [3]. Many recreational athletes juggle sports with academic or work commitments, leading to irregular sleep schedules and cumulative sleep debt [15]. Since sleep quality is a modifiable factor, identifying its impact on neuromuscular performance could help recreational athletes optimize training outcomes while minimizing injury risks.

The CKCUEST is a reliable tool for assessing upper-body stability and endurance in athletes [7]. It mimics functional movements seen in sports, making it a practical measure of neuromuscular control [16]. Previous studies have established its validity in detecting performance deficits related to fatigue or injury [7]. but its association with sleep quality remains unexplored. Neuromuscular performance can be noted as athletic performance by this means.

Research Gap and Objectives: While numerous studies have examined sleep and performance in elite athletes, limited research exists on recreational athletes [17]. This study seeks to fill that gap by evaluating whether poor sleep quality correlates with reduced neuromuscular performance in recreational athletes. The findings could inform sleep education programs and performance strategies tailored to this population.

Aim: Examine the association between sleep quality and neuromuscular performance in recreational athletes.

Objectives:

1. To assess sleep quality in recreational athletes using the Mirani's Assessment for Sleep Quality, Alertness & Functioning Impact in Sports Scale/Questionnaire (MASQAFIS scale/questionnaire) [18].
2. To evaluate neuromuscular performance in recreational athletes using measures of Closed Kinetic Chain Upper Extremity Stability Test.
3. To analyze the relationship between sleep quality and neuromuscular performance in recreational athletes.
4. To examine differences in sleep quality and neuromuscular performance between male and female recreational athletes.

Methodology

This study employed a cross-sectional observational design, utilizing convenient sampling to recruit participants. The study population comprised recreational athletes and active early adults. A total of 244 participants were included, which exceeds the estimated sample size of 217 calculated using G*Power software. Data collection spanned a period of six months and took place at SPB Physiotherapy College, Veer Narmad South Gujarat University, and SMC Adajan Sports Complex, all located in Surat.

The inclusion criteria were: male and female participants aged 18 years and above; recreational and professional athletes; undergraduate and postgraduate student-athletes; and working professionals active in any sport for at least one year. Exclusion criteria were: participants below 18 years of age; those with musculoskeletal injuries within the preceding three months; individuals with a history of neurological or cardio-respiratory conditions; participants with any systemic involvement; those unwilling to participate; and individuals playing sports for less than one year.

The primary outcome measure was the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST). This was quantified by the total number of successful touches made by each participant within a 15-second duration. The best score from three trials was recorded, reflecting upper extremity stability, coordination, and endurance, while maintaining proper form.

Prior to testing, participants received an oral explanation of the test, were screened for eligibility, provided informed consent, and completed the MASQAFIS Scale for sleep quality. Both male and female participants performed the test in the same standardized manner. Participants assumed a push-up position with their hands placed inside two tape lines, set 91.4 cm (36 inches) apart, and their feet positioned at shoulder width.

During the CKCUEST, participants alternated reaching with each hand across their body to touch the opposing tape lines as many times as possible within 15 seconds.

The test duration commenced when the participant indicated readiness and began the test, and concluded when the tester verbally indicated the 15-second completion. Throughout the test, participants were required to maintain a straight, flat back, keep their hands and shoulders perpendicular to ensure adequate weight distribution across the upper limbs, and prevent their knees from contacting the ground.

The examiner counted and recorded the number of touches and the test completion time. Verbal cueing was provided by the evaluators during the test to encourage maximal participant effort (this aspect may be subjective).

Each participant performed three trials, with a 45-second rest period between trials. The highest score from the three trials was recorded as the performance score.

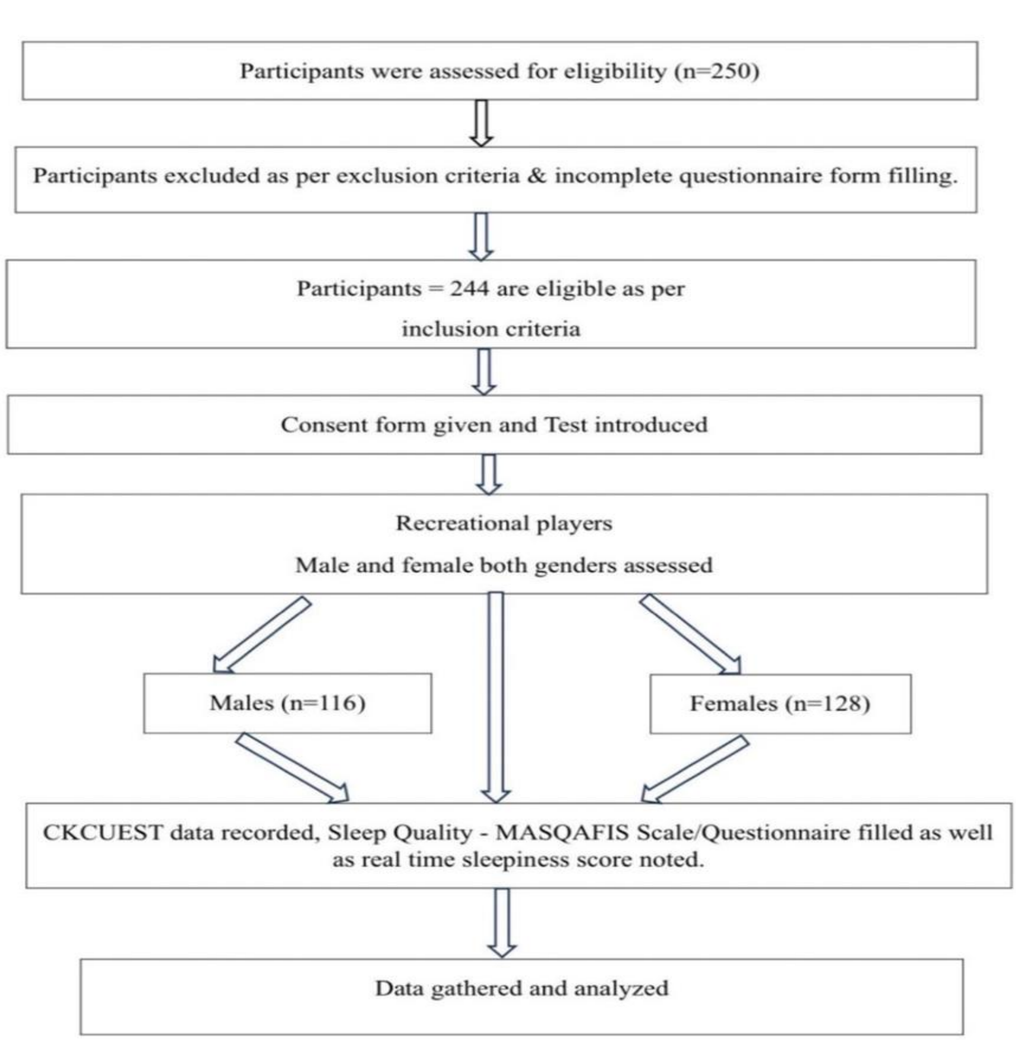
Fig.1: Positioning for performing the CKCUEST Starting position (Anterior view)

Fig 2: Starting position (Lateral view)

Fig 3: Execution of touch to complete the test (Anterior view)

Fig 4: Execution of touch to complete the test (Lateral view)

Chart 1: **Methodology Flow Chart**



Statistical analysis

The data were analysed using IBM SPSS Statistics version 16 to assess the relationship between CKCUES Test Results, Total Score, and Real-Time Score. Given the sample size (N = 244) and the presence of two groups (male and female), the normality of the data was first examined using the Kolmogorov-Smirnov and Shapiro-Wilk tests.

The results indicated that the data did not meet the assumption of normality ($p < 0.05$ for multiple variables), necessitating the use of Spearman's rank correlation coefficient for non-parametric correlation analysis. The significance level was set at $p < 0.05$.

Results

1. Test of Normality

The normality tests (Kolmogorov-Smirnov and Shapiro-Wilk) had been done and indicated that:

CKCUES Test Results were not normally distributed for females (p = 0.000) but were closer to normal for males (p = 0.111).

The Total Score was not normally distributed for females (p = 0.005) but showed no significant deviation for males (p = 0.077).

Real-Time Score was not normally distributed for both males and females (p = 0.000).

Due to these results,

Non-parametric Spearman's rank correlation was applied.

2. Correlation Analysis:

The Spearman's correlation test was conducted to assess the relationships between CKCUES Test Results, Total Score, and Real-Time Score. The findings are summarized in the table below:

Table 1: Correlation analysis

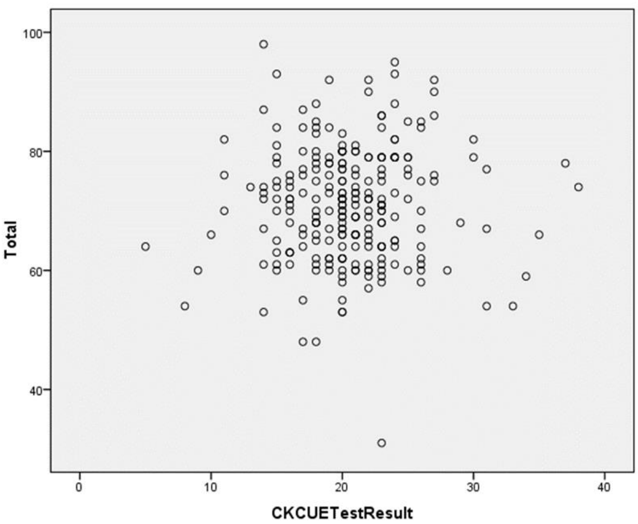
Variable 1	Variable 2	Spearman's rho (ρ)	p-value	Interpretation
CKCUES Test Result	Total Score	0.042	0.514	No correlation
CKCUES Test Result	Real-Time Score	0.010	0.873	No correlation
Total Score	Real-Time Score	-0.101	0.117	No correlation

Interpretation of Findings

CKCUES Test Results and Total Score: A weak positive correlation (ρ = 0.042) was observed, but it was not statistically significant (p = 0.514).

CKCUES Test Results and Real-Time Score: A near-zero correlation (ρ = 0.010), indicating no meaningful relationship (p = 0.873).

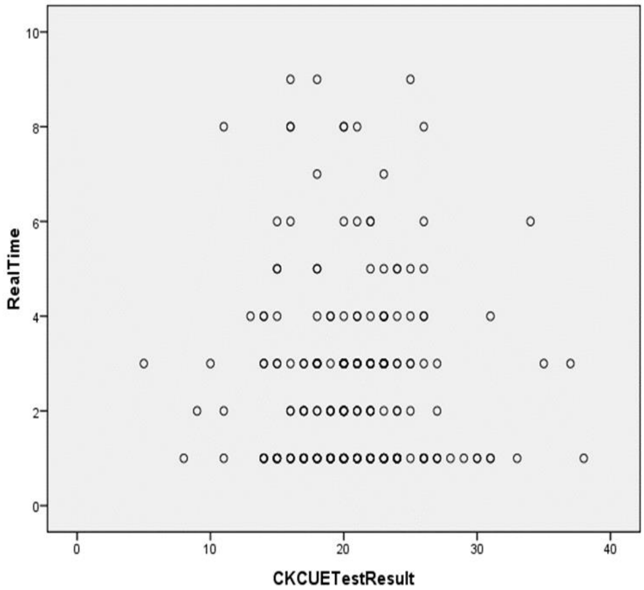
Total Score and Real-Time Score: A weak negative correlation (ρ = -0.101), but it was also not statistically significant (p = 0.117).



Graph/Chart 2: Correlation between CKCUES Test Results and Total score

The scatter plot suggests no strong relationship between CKCUES Test Results and Total Score.

The spread is relatively uniform without a distinct pattern, reinforcing the low correlation coefficient seen in the analysis.

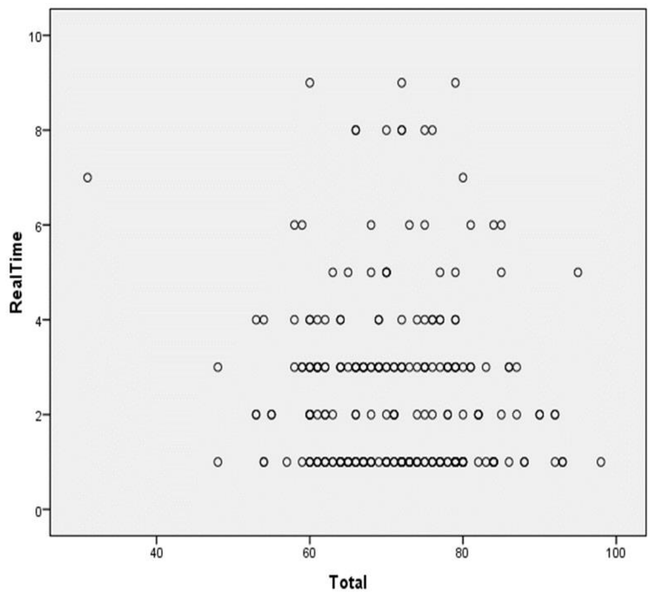


Graph/Chart 3: Correlation between CKCUES Test Results and Real Time

The scatter plot suggests no meaningful correlation between CKCUES Test Results and Real Time.

The triangular pattern indicates that most individuals had Real Time values in the lower range, with fewer participants showing higher values.

This supports the statistical findings that CKCUES Test Results do not significantly predict Real Time performance.

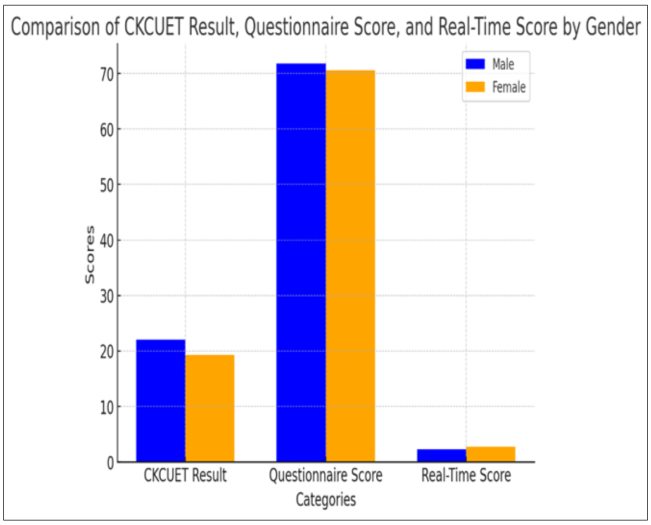


Graph/Chart 4: Correlation between Total Score and Real time

The scatter plot suggests no strong correlation between Total Score and Real Time.

The weak negative trend (-0.101) indicates that as Total Score slightly increases, Real Time might decrease, but this relationship is not significant.

The triangular clustering suggests that most participants had lower Real Time values regardless of their Total Score.



Graph/Chart 5: Bar chart containing Mean comparison between CKCUEST Result, Questionnaire Score, and Real Time Score

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This bar chart represents the Mean and Standard Deviation (SD) of CKCUEST results, total questionnaire scores, and real-time scores for both male and female participants:

CKCUEST Result: Males have a higher mean score (22.03 ± 5.42) compared to females (19.31 ± 3.14).

Total Questionnaire Score: Males have a slightly higher mean (71.80 ± 10.34) than females (70.56 ± 8.92), but the difference is minor.

Real-Time Score: Females have a higher mean real-time score (2.77 ± 1.90) than males (2.31 ± 1.77), indicating possible differences in task execution speed or reaction time.

Discussion

The present study investigated the association between sleep quality and neuromuscular performance in recreational athletes using the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) and the Mirani's Assessment for Sleep Quality, Alertness & Functioning Impact in Sports Scale/ Questionnaire (MASQAFIS). While primary analysis did not reveal a statistically significant correlation between sleep quality and CKCUEST performance ($\rho = 0.042$, $p = 0.514$), these findings contributed to the growing body of literature examining the complex relationship between sleep and athletic performance. The results warranted careful interpretation within the context of existing research and consideration of several methodological and physiological factors.

These null findings contrasted with several studies demonstrating clear relationships between sleep quality and athletic performance. One study in 2022 had been conducted a comprehensive review showing that poor sleep negatively impacts reaction time, accuracy, and endurance in athletes. [2] Similarly, another study in 2015 reported that even partial sleep deprivation (≤5 hours per night) impairs neuromuscular function, particularly in sports requiring precision and coordination [8].

The discrepancy between these studies and current results may stem from differences in study populations, while previous research primarily examined elite athletes, current study focused on recreational athletes who might have different physiological adaptations or compensatory mechanisms.

Interestingly, current findings aligned with some recent studies suggesting that the effects of sleep disruption may be task-specific. There was one study found that upper-body closed kinetic chain tests like the CKCUEST may be less sensitive to sleep deprivation compared to open-chain or reaction-time-based assessments [16]. This could explain why in this study did not observe significant performance declines despite variations in sleep quality among participants.

Additionally, another noted that well-trained athletes often develop resilience to mild sleep disturbances, which may apply to experienced recreational athletes in current sample [4].

Unlike elite athletes, who often operate near physiological thresholds, recreational athletes might possess greater performance buffers that mitigate the effects of suboptimal sleep. There was one study proposed that moderate training loads - common in non-elite populations, may not push athletes to a point where sleep deficits substantially impair performance [10].

This aligns with findings with other study which, observed that university athletes maintained consistent performance despite sleep fluctuations during academic stress periods [3]. Current results supported the notion that recreational athletes may be less susceptible to sleep-related performance decrements, possibly due to lower overall physical demands compared to competitive athletes.

The CKCUEST primarily assesses muscular endurance and stability rather than explosive power or reaction time domains that prior research has shown to be more sensitive to sleep deprivation [15, 19]. For instance, studies utilizing vertical jump or sprint tests consistently report performance declines following sleep restriction [20], whereas closed-chain stability tests might be more resistant to such effects.

Similarly, another study noted that upper-body closed-chain assessments exhibit high reliability even under suboptimal conditions [16]. Thus, the nature of the CKCUEST may partially explain the null findings, suggesting that sleep has a more pronounced impact on explosive or reactive tasks than on sustained stability performance.

The reliance on self-reported sleep data (via the MASQAFIS scale/questionnaire) might have limited our ability to detect subtle but biologically meaningful sleep variations. Objective measures, such as actigraphy [21] or polysomnography, could provide more precise sleep metrics in future investigations.

Additionally, the cross-sectional design precluded causal inferences; longitudinal tracking of sleep and performance changes might reveal different patterns over time [22]. Future studies should consider incorporating multi-method sleep assessments and experimental designs to better elucidate these relationships.

Secondary analyses revealed that male participants outperformed females on the CKCUEST (22.03 vs. 19.31 touches), which aligned with established sex-based differences in upper-body strength [23]. Females also reported higher real-time sleepiness scores (2.77 vs. 2.31), potentially reflecting hormonal influences on sleep perception [24]. These findings are consistent with another study, which documented gender disparities in both sleep architecture and athletic performance [25].

However, the clinical relevance of these differences in recreational populations remained uncertain and warrants further investigation, particularly regarding whether tailored sleep or training interventions could mitigate performance gaps.

Conclusion

The study assessed the correlation between CKCUEST results, questionnaire total scores, and real-time scores among male and female participants. The results indicated no significant correlation between the variables, suggesting that the tested parameters may not have a strong interdependence in this context.

Additionally, males showed slightly higher mean CKCUEST results and questionnaire scores, while females had higher real-time scores.

However, these differences were not statistically significant. The findings emphasize the need for further research to explore other contributing factors that may influence these outcomes.

Limitations of the study

Sample Representation: The study was limited to recreational players, which may not be representative of the broader athletic population.

Cross-Sectional Design: As a cross-sectional study, it only provides a snapshot in time and does not capture longitudinal changes.

Self-Reported Data: The questionnaire scores relied on self-reported responses, which could be influenced by bias.

Lack of Additional Variables: Other potential influencing factors, such as physical fitness levels, training history, and external environmental factors, were not considered.

Use of Non-Parametric Tests: Due to the non-normal distribution of some data, non-parametric correlation tests were used, which may limit the ability to generalize findings.

Future Scope

Incorporating Larger and More Diverse Samples: Expanding the study across different athletic populations and demographics to enhance generalizability.

Longitudinal Analysis: Conducting a longitudinal study to track changes over time and determine causal relationships.

Exploring Additional Variables: Including physiological and biomechanical factors that may impact CKCUEST performance and real-time response.

Developing a Comprehensive Model: Creating predictive models integrating various physical and cognitive performance measures.

Intervention-Based Studies: Investigating the impact of training interventions on test scores and real-time performance to determine effective strategies for improvement.

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