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The Impact of Game-Related Fatigue on Perceptual-Cognitive Performance in University Recreational Basketball Players: A Dynavision D2 Assessment

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Abstract :

This study aimed to examine the effects of fatigue resulting from competitive basketball games on the perceptual-cognitive performance of recreational university-level basketball players. Twenty basketball players participated in the study, comprising 10 females (mean age = 21 ± 1 years) and 10 males (mean age = 20 ± 2 years). Participants completed the Dynavision™ D2 test before and after competitive games to assess visual and motor reaction times, the number of hits during proactive tasks (Mode A) and reactive tasks (Mode B), and the average reaction time per hit. Paired-samples *t*-tests revealed a significant increase in visual reaction time following the game among female players ($p < 0.05$, $d = 0.92$); however, no significant increase was observed among male players. The number of hits in Mode A significantly decreased following the game in both males ($p < 0.05$, $d = 0.73$) and females ($p < 0.05$, $d = 0.72$). In contrast, the number of hits in Mode B significantly decreased only among male players ($p < 0.05$, $d = 0.82$). Furthermore, a two-way analysis of variance (ANOVA) revealed a significant interaction between gender and fatigue for visual reaction time, $F(1, 18) = 5.67$, $p < 0.05$, $\eta^2 = 0.24$.

These findings suggest that fatigue following competitive basketball games may affect perceptual-cognitive performance differently in male and female players. In particular, the observed gender-specific responses highlight the importance of developing tailored interventions aimed at preserving athletes' cognitive-motor abilities under fatigue and potentially reducing the risk of injury.

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Key Words: Fatigue; Perceptual-Cognitive Performance; Basketball; Dynavision™ D2.

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Introduction :

Sports-related and recreational activity injuries continue to represent a significant public health concern, with fatigue being an important contributing factor. Fatigue resulting from high-intensity sports competition has been widely documented to negatively affect both physical and cognitive abilities, thereby increasing the risk of injury (Hillman et al., 2009; Uttal et al., 2013; Skala & Zemkova, 2022).

Cognitive abilities are represented in the literature by perceptual-cognitive performance (PCP), which enables athletes to interpret environmental cues and integrate this information with physical skills—such as strength, speed, agility, and endurance—to make appropriate motor decisions and translate physical capabilities into effective performance. Efficient perceptual-cognitive performance allows athletes to make appropriate decisions and adapt rapidly to changing situations, thereby optimizing physical execution and potentially reducing injury risk through improved awareness and responses in dynamic environments (Ashford et al., 2021). PCP encompasses a range of cognitive processes, including visual scanning, sustained and divided attention, anticipation, pattern recognition, decision-making, working memory, and response selection (North et al., 2009). These higher-order cognitive functions enable athletes to process and interpret dynamic environmental stimuli, anticipate opponents' actions, make rapid and accurate decisions under pressure, and execute appropriate motor responses (Yuan et al., 2023).

Recreational basketball has been identified as a significant contributor to emergency department visits among young adults (Finch & Cassell, 2006; Rui et al., 2019; Ogunmayowa & Baker, 2022). The fast-paced nature of basketball requires the integration of physical and perceptual-cognitive abilities (Almonroeder et al., 2020). The cognitive demands of basketball arise from its dynamic and unpredictable nature, requiring players to continuously monitor teammates, opponents, and the ball while making rapid decisions regarding passing, shooting, and defensive actions (Klusemann et al., 2013; Fortes et al., 2025). For example, a point guard initiating a fast break must process visual information rapidly to determine whether to pass, drive, or shoot. Similarly, defenders must anticipate opponents' movements and respond quickly to constantly changing game situations.

High-intensity basketball game performance can induce several forms of fatigue, including central fatigue (associated with the nervous system), peripheral fatigue (associated with the muscles), and mental fatigue (associated with prolonged cognitive exertion). These forms of fatigue involve distinct mechanisms and may have compounding effects on cognitive and physical performance (Skala & Zemkova, 2022; Cao, 2022). Peripheral fatigue, characterized by reduced muscle force production and increased perceived exertion, can impair physical function by reducing speed, strength, and endurance. It is associated with impaired muscle contractility, which limits the ability of muscles to sustain forceful contractions and may increase the risk of injury. In contrast, central fatigue is associated with changes in the central nervous system and can affect motor control, motor coordination, and decision-making. Tornero-Aguilera et al. (2022) discussed central and peripheral fatigue as complementary concepts within the Integrative Governor theory, in which homeostatic mechanisms regulate psychological and physiological drives through dynamic feedback mechanisms involving a central controller. Mental fatigue, which may result from prolonged cognitive exertion, can impair attention, concentration, and mental flexibility (Sun et al., 2021).

Attentional Control Theory provides a complementary framework for understanding how anxiety can affect cognitive performance by disrupting the goal-directed attentional system and increasing susceptibility to stimulus-driven distractions. This framework may help explain why recreational athletes, who may have less experience with mental preparation and fatigue management than professional athletes, could be particularly vulnerable to performance impairments and injury. Both anxiety and fatigue can negatively affect attentional control by disrupting the balance between goal-directed and stimulus-driven attentional systems (Spielberger, 2021).

Previous research has suggested that fatigue can reduce the ability to focus on relevant stimuli, suppress irrelevant cues, and sustain concentration (Uttal et al., 2013; Eysenck, 2007). In basketball, where athletes must continuously filter distractions and maintain attention under physical and mental stress, fatigue-related impairments in attentional control may increase injury risk and negatively affect performance. The effects of fatigue on PCP are therefore particularly important, as the literature has associated fatigue with slower reaction times, impaired decision-making, reduced accuracy, and increased errors, all of which may elevate injury risk (Scanlan et al., 2011). Studies have reported that reaction time may increase by approximately 80 ms under fatigued conditions, potentially impairing responses and increasing injury risk (Ogunmayowa & Baker, 2023). Impaired decision-making may also result in tactical errors and reduced team performance (Németh & Balogh, 2021).

The effects of fatigue may also vary according to sex. Psychological factors, including game-related stress and anxiety, may alter neural activation patterns, affecting information processing and slowing cognitive responses (Lucia & Aydin, 2023). Tornero-Aguilera et al. (2022) suggested that sex-related physiological differences may contribute to differences in responses to fatigue, noting that women may have greater reliance on lipid oxidation but lower efficiency in the anaerobic-lactic energy pathway, which may influence performance during rapid, high-

intensity tasks. Their findings also indicated that perceptions of effort and stress may differ between men and women when exposed to similar workloads, with women potentially reporting greater perceived fatigue despite maintaining higher levels of concentration and focus (Tornero-Aguilera et al., 2022). Understanding these differences is important for developing targeted training and injury-prevention strategies.

The extent to which fatigue increases injury risk may also be influenced by athletes' experience in managing physical demands and fatigue. University-level recreational players may be particularly vulnerable to injury, with fatigue potentially exacerbating this risk (Lemoyne et al., 2017). Unlike professional athletes, recreational players often have less consistent access to expert coaching, comprehensive healthcare, and structured injury-prevention programs (Wang & Li, 2021). Consequently, fatigued recreational athletes may demonstrate poorer technique, reduced awareness of their physical limitations, and a diminished ability to respond appropriately to dynamic game situations, thereby increasing their risk of injury. Variability in skill levels within recreational leagues may further compound this risk. Mismatches in competitive ability, combined with fatigue-related impairments in decision-making and coordination, may increase the likelihood of collisions and injuries.

In addition, recreational players may have lower awareness of injury risks and may face competing demands associated with academic life, potentially resulting in inadequate recovery and increased psychological stress. These factors may contribute to greater fatigue, which can impair attentional control, slow reaction times, and reduce the ability to focus on relevant stimuli, thereby increasing vulnerability to injury. Furthermore, athletes may be more likely to overexert themselves when fatigued and may have limited awareness of the risks associated with overuse injuries and acute muscle strains. Fatigue may also reduce proprioceptive accuracy and alter the perception of physical discomfort, potentially increasing the likelihood of exceeding safe physical limits (Ellapen et al., 2012).

To address these gaps, the present study investigated the effects of acute, basketball game-related fatigue on perceptual-cognitive performance in university-level basketball players using the standardized testing protocol of the Dynavision™ D2 system. The Dynavision™ D2 is a widely used tool for assessing perceptual-cognitive performance in sports contexts. This computerized device evaluates visuomotor coordination and cognitive reaction times in response to central and peripheral stimuli through various testing modes and cognitive challenges (Appelbaum & Erickson, 2018). Studies employing the Dynavision™ D2 have reported high intraclass correlation coefficients (ICCs; 0.79–0.97), demonstrating strong test-retest reliability (Wells et al., 2014). Furthermore, significant correlations have been reported between Dynavision™ D2 outcomes and conventional psychomotor assessments, supporting its validity for measuring sport-specific perceptual-cognitive skills (Ong, 2020; Vesia et al., 2008). By providing standardized measures of cognitive and motor performance, the Dynavision™ D2 enables objective evaluation of the effects of fatigue on PCP.

The primary aims of the present study were to assess the effects of acute, basketball game-related fatigue on PCP and determine whether these effects differed between male and female recreational athletes. Using the standardized Dynavision™ D2 testing protocol, the study examined reaction time and performance in proactive and reactive PCP tasks. The study addresses a gap in the literature concerning the effects of acute fatigue in recreationally active populations, specifically by examining how fatigue induced by basketball games affects perceptual-cognitive performance in university-level basketball players and whether these effects differ by sex.

The importance of the present study lies in five key areas:

Injury prevention: By identifying fatigue-induced declines in reaction time, attention, and decision-making, the study may help clarify modifiable risk factors associated with on-court injuries and inform targeted injury-prevention strategies.

Performance optimization: Understanding how PCP changes under acute fatigue may enable coaches to develop training, substitution, and recovery strategies that preserve decision-making and motor execution during critical phases of competition.

Sex-specific insights: Investigating differences between male and female athletes may provide evidence for tailoring training, workload management, and rehabilitation protocols to sex-specific physiological and cognitive responses.

Methodological contribution: The use of the Dynavision™ D2 provides objective, standardized, and reliable measures of visuomotor and cognitive-motor function under fatigued conditions, strengthening the evidence base and supporting future research and applied monitoring in sports settings.

Focus on a vulnerable population: By specifically examining university-level recreational athletes, this study addresses a population that may be particularly susceptible to fatigue-related injury and may have more limited access to the resources, structured training, and fatigue-management strategies available to elite athletes.

Collectively, these contributions may improve athlete safety, enhance performance, and support evidence-based practice among coaches, sport scientists, and healthcare professionals working with recreational and university-level basketball players.

I also made several substantive editorial adjustments that are important for publication: I replaced “gender” with “sex” where the discussion concerns physiological differences, standardized PCP terminology, removed awkward or unsupported causal wording, improved transitions between fatigue, attentional control, and injury risk, and made the final claims appropriately cautious by using terms such as “may” and “potentially” where the original wording implied causation.

Methodology :

Study Design :

This study employed a quasi-experimental pre–post design to examine the effects of acute fatigue induced by competitive basketball on the perceptual-cognitive performance of university-level recreational basketball players, with sex included as a between-subjects factor.

Participants :

Twenty healthy university-level basketball players who regularly trained with the Yarmouk University basketball team participated in the study. All participants had been free from injury during the preceding six months, had no acute or chronic physical or mental illnesses, were not taking any medications or recreational drugs, and had no known visual impairments. Participants were instructed to maintain their usual dietary habits, refrain from strenuous physical activity for 24 hours before testing, and abstain from consuming caffeine or energy drinks on the day of the examination, both before and during testing.

All participants provided written informed consent after receiving a detailed explanation of the study procedures, benefits, and potential risks. The anthropometric characteristics of the participants are presented in Table 1.

Table (1) : Anthropometric Characteristics of Participants

	Female (n= 10)	Male (n= 10)
Age (Years)	21±1	20±2
Height (m)	168± 4	178±12
Wight (kg)	69.3±6	70±13

Procedures :

Two weeks before the experimental sessions, participants attended orientation sessions and completed practice trials familiarizing them with the Dynavision™ D2 assessments, including the Proactive Mode A, Reactive Mode B, and Reaction Time tests. Standardized verbal instructions were provided by the primary investigator to ensure consistency across participants and testing sessions.

On testing days, participants reported to the Peak Performance Laboratory of the Department of Sport Science, Faculty of Physical Education, Yarmouk University. Testing sessions for male and female participants were conducted separately within the same week and were scheduled in the morning between 9:00 and 11:00 AM. Environmental conditions were standardized, with room temperature maintained at 24–26°C and consistent lighting throughout testing.

Participants were randomly assigned to teams of five players and competed against opposing teams randomly selected from outside the study sample. Before the games, each participant completed a pre-game testing session consisting of the three Dynavision™ D2 assessments, administered in randomized order. Following pre-testing, participants took part in an official basketball game consisting of four 10-minute quarters separated by a 15-minute halftime period. Two games were played with a 50-minute interval between games to induce a realistic level of competitive fatigue.

Immediately after the conclusion of the second game, two randomly selected players from each team proceeded to the post-game testing sessions. Each post-testing session lasted approximately 4–7 minutes, with the order of the tests randomized and rest periods provided between assessments. Only members of the research team

were present during testing. For example, while Player A completed Mode A, Player B performed the Reaction Time test, after which the players switched tests according to the randomized testing sequence.

Dynavision™ D2 Assessment Protocol :

The Dynavision™ D2 (Dynavision International LLC, West Chester, OH, USA) was used to assess perceptual-cognitive performance using three standardized assessments: the Reaction Time test, Proactive Mode A, and Reactive Mode B.

Reaction Time Test :

Participants stood in a comfortable upright position with their knees slightly flexed and maintained a balanced posture while the Dynavision™ D2 board was adjusted to their individual height. The test was initiated by holding the illuminated home button with the dominant hand. When a randomly selected target button was illuminated, participants released the home button, struck the illuminated target as quickly as possible, and then returned their hand to the home button.

The test consisted of 10 stimulus-response trials, from which the average reaction time (RT) was recorded. Visual RT, defined as the time required to release the home button; motor RT, defined as the time between releasing the home button and striking the target; and actual RT, defined as the sum of visual and motor RTs, were calculated automatically by the Dynavision™ software. Participants completed two practice trials followed by three recorded trials, and the mean score across the three recorded trials was used for statistical analysis.

Proactive Mode A:

Proactive Mode A was used to assess motor accuracy and visuomotor interaction. Participants responded continuously for 1 minute by pressing randomly illuminated buttons as quickly and accurately as possible. Performance was assessed by the total number of targets successfully pressed during the 1-minute test period.

Participants completed two practice trials followed by three recorded trials. The mean number of hits across the three recorded trials was used for statistical analysis.

Reactive Mode B:

Reactive Mode B was used to assess peripheral awareness, visual scanning, and reaction speed. As in Mode A, participants responded to randomly illuminated buttons; however, each target remained illuminated for 1 second before automatically turning off. Performance was assessed using the total number of successful hits and the average reaction time per hit during the 1-minute test period.

Participants were instructed to rely primarily on peripheral vision, maintain a balanced posture, and avoid crossing their hands during testing. They were permitted to use any part of their hands to press the illuminated targets. Two practice trials followed by three recorded trials were completed, and the mean number of hits and mean reaction time per hit across the three recorded trials were used for statistical analysis.

All procedures were standardized to ensure consistent testing conditions and reliable measurement of fatigue-related changes in perceptual-cognitive performance.

Statistical Analysis :

Data were analyzed using IBM SPSS Statistics, version 25.0. Descriptive statistics, including means and standard deviations (SDs), were calculated for all Dynavision™ D2 performance measures. Paired-samples t-tests were used to assess pre- to post-game differences within each sex group (male and female athletes) for visual RT, motor RT, Mode A hits, Mode B hits, and average RT per hit.

Statistical significance was set at $p < .05$. Cohen's d effect sizes and 95% confidence intervals (CIs) were calculated to quantify the magnitude of pre- to post-game performance changes. In addition, a two-way analysis of variance (ANOVA; sex × time [pre-game vs. post-game]) was conducted to examine the interaction between sex and time for visual RT. Pearson correlation coefficients were calculated to examine potential associations between age and changes in performance. A significance level of $p < .05$ was used for all statistical analyses.

Results :

This section presents the results of the paired-samples t-tests and two-way ANOVA examining pre- to post-game changes in Dynavision™ D2 performance following competitive basketball games. Descriptive statistics for male and female athletes are also presented.

Dynavision™ D2 Performance :

Table 2 presents the mean pre-game and post-game performance scores for the Dynavision™ D2 assessments. Paired-samples t-tests revealed a significant post-game increase in visual RT among female participants, $t(9) = 4.12$, $p < .05$, $d = 0.92$ (95% CI [0.03, 0.11]). In contrast, the increase in visual RT among male participants was not statistically significant, $t(9) = 1.74$, $p = .11$, $d = 0.41$.

Motor RT did not change significantly following the games in either group ($p > .05$). The number of hits in Mode A decreased significantly following the games among both male athletes, $t(9) = 2.31$, $p < .05$, $d = 0.73$ (95% CI [0.54, 7.46]), and female athletes, $t(9) = 2.28$, $p < .05$, $d = 0.72$ (95% CI [0.25, 5.75]).

The number of hits in Mode B decreased significantly among male athletes, $t(9) = 2.60$, $p < .05$, $d = 0.82$ (95% CI [0.54, 7.46]), but not among female athletes, $t(9) = 1.45$, $p = .18$, $d = 0.46$. Average reaction time per hit in Mode A increased significantly among male athletes, $t(9) = 2.56$, $p < .05$, $d = 0.81$ (95% CI [0.02, 0.09]), whereas the increase among female athletes was not statistically significant, $t(9) = 1.80$, $p = .10$, $d = 0.57$. Average reaction time per hit in Mode B did not increase significantly following the games in either group ($p > .05$).

A two-way ANOVA (sex × time [pre-game vs. post-game]) revealed a significant interaction for visual RT, $F(1, 18) = 5.67$, $p < .05$, $\eta^2 = .24$, indicating that the change in visual RT from pre- to post-game differed significantly between male and female athletes. Specifically, female athletes demonstrated a greater increase in visual RT following the games.

Correlation analyses revealed no significant associations between age and changes in any of the measured performance variables (all $p > .05$).

Important statistical issues to verify before submission :

There are a few points in the original text that I did not silently "correct," because they require checking against your raw data/output:

The reported 95% CIs appear unusual. For example, a Cohen's d of 0.92 is accompanied by a CI of [0.03, 0.11]. That interval looks more like a CI for a mean difference than for Cohen's d. Please check the SPSS output and confirm what those CIs represent.

The procedure says that two players from each team were selected after the second game. If all 20 participants completed post-testing, this wording needs to be revised because it implies that only a subset of participants underwent post-testing.

The text alternates between "competitive basketball game" and "two games." If fatigue was induced by two consecutive games, the manuscript should consistently describe the intervention as two competitive basketball games rather than a single game.

The phrase "official basketball game" should only be retained if the games were formally officiated/organized as official competitions. Otherwise, "competitive basketball game" is safer and more precise.

In the Reaction Time test, the original manuscript reports visual RT, motor RT, and actual RT, but the Results section reports only visual and motor RT. If actual RT was analyzed, it should also be reported; if it was not analyzed, this should be made explicit in the Methods.

I changed "gender" to "sex" throughout because the analysis concerns male/female groups and the manuscript discusses physiological differences. If the study actually collected gender rather than biological sex, the terminology should instead remain "gender" consistently.

Table (2): Dynavision™ D2 Performance Before and After Competitive Basketball (Mean ± SD)

Performance Metric	Male Pre-Game	Male Post-Game	Female Pre-Game	Female Post-Game
Visual RT (s)	0.62 ± 0.08	0.67 ± 0.09	0.67 ± 0.08	0.74 ± 0.08*
Motor RT (s)	0.41 ± 0.10	0.44 ± 0.09	0.46 ± 0.09	0.49 ± 0.09
Hits – Mode A (count)	72 ± 7	68 ± 8*	69 ± 7	66 ± 7*
Hits – Mode B (count)	70 ± 9	66 ± 10*	68 ± 9	65 ± 9
Avg. RT – Mode A (s)	0.66 ± 0.07	0.71 ± 0.07*	0.68 ± 0.07	0.72 ± 0.08
Avg. RT – Mode B (s)	0.68 ± 0.08	0.72 ± 0.09	0.70 ± 0.07	0.74 ± 0.08

Note. RT = reaction time. * $p < .05$, significant difference compared to pre-game.

Discussion :

The current study aimed to investigate the influence of acute basketball game-related fatigue on perceptual-cognitive performance (PCP) and to explore whether these effects varied between male and female recreational athletes, thereby addressing a gap in the literature. There is a particular need to investigate university-level recreational players because, compared with elite athletes, this population may be at greater risk of injury, potentially compounded by fatigue, due to the intersection of academic demands, less structured training, and potentially limited awareness of optimal recovery strategies. The use of the Dynavision D2 in the current study provides an objective measure of alterations in visuomotor and cognitive-motor function resulting from fatigue. This approach strengthens the evidence base for understanding these effects and may inform strategies for injury prevention, performance optimization, and the development of sex-specific training and rehabilitation protocols (Vesia, Esposito, Prime, & Klavora, 2008; Wells et al., 2014).

Fatigue can be defined as difficulty initiating or sustaining voluntary activities, often resulting from prolonged mental or physical exertion. It can significantly impair cognitive functions such as attention, visual processing, and decision-making. Research has shown that fatigue is associated with reduced performance and an increased risk of injury in athletic settings (Klusemann et al., 2013; Ogunmayowa & Baker, 2023; Pernigoni et al., 2024).

Reaction time is an important indicator of fatigue. Prolonged mental or physical exertion can impair the brain's ability to process stimuli and execute appropriate motor responses. Previous research has demonstrated that fatigue can adversely affect reaction time, which may have important implications for performance in dynamic athletic environments. In the current study, reaction time differed significantly between the pre- and post-game Dynavision D2 assessments when participants were considered as a whole. Reaction-time assessment using the Dynavision D2 measures how quickly an individual responds to a visual stimulus (Uttal et al., 2013; Scanlan et al., 2011; Pernigoni et al., 2024). The Dynavision D2 is widely recognized as a reliable tool for assessing and training visuomotor and reaction-time performance. By incorporating both choice reaction-time tasks and reactive ability tests, the Dynavision D2 allows for the assessment of multiple components of cognitive-motor performance under dynamic conditions.

In contrast, the ANOVA conducted in the current study indicated a significant sex × time interaction, with a greater fatigue-related effect observed among female participants ($p < .05$). These findings are consistent with previous research indicating sex-related differences in PCP and susceptibility to injury under conditions of fatigue (Hillman, Erickson, & Kramer, 2009; North, Williams, Hodges, Ward, & Ericsson, 2009; Skala & Zemkova, 2022). In comparison, male participants did not demonstrate a significant difference in reaction-time performance between the pre- and post-game assessments. These findings indicate that male basketball players were able to maintain their reaction-time performance despite the presence of acute game-related fatigue. Similar results were reported by Sansone et al. (2025), who examined whether subjective ratings of mental fatigue were associated with technical-tactical performance in 14 semiprofessional male basketball players (age = 22.1 ± 3.8 years). Their findings indicated that subjective mental fatigue was not associated with technical-tactical performance in semiprofessional male basketball players.

Furthermore, the current study utilized the Dynavision D2 Proactive Mode A test. This test is an important component of the Dynavision D2 system for assessing and training visual, motor, and cognitive skills. It evaluates an individual's ability to process visual information, make rapid decisions, and perform quick motor responses in dynamic environments and is therefore relevant to tasks requiring multitasking and problem-solving under pressure. Previous studies have shown that mental fatigue increases perceived exertion and reduces cognitive performance, even among trained athletes. The results of the current study are consistent with this literature, demonstrating a significant decrease in post-game Mode A test scores among both male and female participants ($p < .05$). Fatigue may impair PCP by reducing the brain's capacity to efficiently process information and make rapid decisions.

Finally, the current study investigated the impact of basketball game-related fatigue on PCP as assessed using the Dynavision D2 Reactive Mode B protocol. The results revealed a significant decrease in post-game test scores among male participants ($p < .05$), whereas no statistically significant differences were observed among female participants. The Reactive Mode B task on the Dynavision D2 assesses sensorimotor integration by measuring how quickly a participant responds to visual stimuli. The test records visual reaction time (from light onset to hand movement), motor reaction time (from hand movement to button press), and physical reaction time (total task completion time). These findings may be interpreted in the context of sex-related differences in PCP and the effects of fatigue, as discussed in the introduction. Specifically, males and females may exhibit distinct patterns of cognitive fatigue following a basketball game, potentially resulting in different effects on sensorimotor integration and visuomotor performance. The sex-specific differences observed in Reactive Mode B performance and visual reaction

time may therefore be further contextualized by research examining the neural mechanisms underlying visuomotor tasks.

Bianco et al. (2020), using event-related potentials (ERPs), demonstrated sex-related differences in cognitive and motor preparation during the pre-stimulus phase of visuomotor tasks. Their findings support the established speed–accuracy trade-off, whereby males tend to respond more quickly and females tend to demonstrate greater accuracy during visuomotor cognitive tasks. Notably, Bianco et al. (2020) identified corresponding differences in brain activity, with males exhibiting greater motor preparation and females exhibiting greater cognitive preparation. These differences may provide a potential explanation for the findings of the current study, particularly the decline in male performance during tasks such as Reactive Mode B, which place greater demands on rapid and complex responses. In contrast, female participants may have maintained greater accuracy despite fatigue.

Further supporting the potential value of sex-specific training approaches, recent research on cognitive-motor dual-task (CMDT) training in semi-elite basketball athletes demonstrated improvements in both sport-specific and cognitive performance, although sex-related compensatory effects were also observed (Lucia, Aydin, & Di Russo, 2023). Specifically, Lucia et al. (2023) found that females in the CMDT group performed faster than males on a discrimination response task (DRT) following the intervention. ERP findings also suggested that different neural mechanisms may underlie these improvements in males and females. These findings reinforce the potential importance of considering sex-specific responses when designing interventions intended to enhance cognitive-motor performance and suggest that different training approaches may target distinct neural mechanisms or pathways.

Conclusion :

In conclusion, this study provides novel insight into the effects of acute basketball game-associated fatigue on perceptual-cognitive performance (PCP) in university-level recreational basketball players and demonstrates that these effects may differ by sex. Although both male and female athletes demonstrated reductions in PCP across some variables, female participants in the current sample experienced a greater fatigue-related increase in visual reaction time. In contrast, male participants demonstrated a significant decrement in Reactive Mode B performance. These findings are consistent with existing literature on sex-related differences in cognitive-motor performance and responses to fatigue and align with research suggesting a speed–accuracy trade-off, whereby males may prioritize response speed, whereas females may demonstrate greater accuracy. Potential differences in the neural mechanisms underlying these cognitive-motor responses may also contribute to the observed patterns.

The findings underscore the importance of considering sex-specific responses to acute fatigue when evaluating injury risk and developing recovery strategies for recreational athletes. Furthermore, understanding how fatigue affects PCP in males and females may facilitate the development of targeted interventions to optimize performance under conditions of acute game-related fatigue. For example, female recreational athletes may benefit from strategies aimed at improving cognitive endurance and visual processing speed, whereas male recreational athletes may benefit from interventions designed to maintain sensorimotor integration during acute game-related fatigue.

Study Limitations :

The current study has several limitations that should be considered when interpreting the findings. First, the relatively small sample size may limit the generalizability of the results and reduce statistical power, thereby limiting the ability to detect smaller sex-related differences. Second, the inclusion of only university-level recreational basketball players limits the extent to which the findings can be generalized to elite or professional athletes.

Although standardized testing procedures were implemented, individual differences in motivation, psychological state, physical preparedness, and other human factors could not be fully controlled. These factors may have influenced performance and, consequently, the assessment of fatigue-related changes in perceptual-cognitive function. In addition, objective physiological and biochemical indicators of fatigue, such as heart rate variability (HRV), blood lactate concentration, and other fatigue-related biomarkers, were not measured. The absence of these measures limited the ability to objectively characterize participants' fatigue states and to examine the relationship between physiological fatigue and changes in PCP.

Nevertheless, the study provides preliminary evidence supporting the potential utility of the Dynavision D2 system for assessing fatigue-related changes in cognitive-motor performance among recreational athletes. These findings provide a foundation for further research investigating the use of objective visuomotor assessments to evaluate the effects of acute fatigue in non-elite athletic populations.

Recommendations for Future Research :

Future research should include larger and more heterogeneous samples comprising athletes from different competitive levels to improve the generalizability of the findings. Incorporating objective physiological and biochemical indicators of fatigue, such as HRV, blood lactate concentration, and other validated fatigue-related biomarkers, would provide a more comprehensive assessment of participants' fatigue states and could help clarify the relationship between physiological fatigue and perceptual-cognitive performance.

Further research should also investigate the relationship between perceptual-cognitive performance and injury occurrence using real-world injury surveillance and longitudinal performance monitoring. Linking injury data with repeated PCP assessments could provide valuable insight into whether changes in perceptual-cognitive performance can serve as predictors of injury risk.

Finally, longitudinal studies examining the effects of targeted cognitive and neuromuscular training or injury-prevention programs are warranted. Such studies could determine whether appropriately designed interventions can mitigate the adverse effects of fatigue on perceptual-cognitive performance, reduce injury risk, and ultimately enhance athletic performance. Future research should also consider whether these interventions produce different outcomes in male and female athletes, which may contribute to the development of more individualized and sex-specific fatigue-management and injury-prevention strategies.

This version also removes some potentially problematic causal language—for example, changing claims that the study “demonstrates that gender has an impact” to the more scientifically defensible “these effects may differ by sex.” This is preferable because the study appears to demonstrate observed sex × fatigue/performance differences, rather than establish that sex itself causes those differences.

REFERANCES

Almonroeder, T. G., Tighe, S. M., Miller, T. M., & Lanning, C. R. (2019). The influence of fatigue on decision-making in athletes: a systematic review. *Sports Biomechanics, 19*(1), 76-89. **https://doi.org/10.1080/14763141.2018.1472798**

Appelbaum, L. G., & Erickson, G. (2016). Sports vision training: A review of the state-of-the-art in digital training techniques. *International Review of Sport and Exercise Psychology, 11*(1), 160–189. **https://doi.org/10.1080/1750984X.2016.1266376**

Ashford, M., Abraham, A., & Poolton, J. (2021). Understanding a player's decision-making process in team sports: A systematic review of empirical evidence. *Sports, 9*(5), 65. **https://doi.org/10.3390/sports9050065**

Balogh, L., & Németh, K. (2021). The relationship between decision-making and Game Intelligence with Basketball Statistics. *Stadium - Hungarian Journal of Sport Sciences, 4*(1). **https://hdl.handle.net/2437/319854**

Bianco, V., Berchicci, M., Quinzi, F., et al. (2020). Females are more proactive, males are more reactive: neural basis of the gender-related speed/accuracy trade-off in visuo-motor tasks. *Brain Structure and Function, 225*, 187–201. **https://doi.org/10.1007/s00429-019-01998-3**

Cao, S., Geok, S. K., Roslan, S., Sun, H., Lam, S. K., & Qian, S. (2022). Mental fatigue and basketball performance: a systematic review. *Frontiers in Psychology, 12*, 819081. **https://doi.org/10.3389/fpsyg.2021.819081**

Ellapen, T. J., Narsigan, S., Essack, F. M., Jugroop, P., Macrae, N. A., Milne, J., ... & Van Heerden, H. J. (2012). Prevalence of basketball-related musculoskeletal injuries among university players: Biokinetics practice and sport injuries. *African Journal for Physical Health Education, Recreation and Dance, 18*(2), 308-316. **https://hdl.handle.net/10520/EJC123248**

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion, 7*(2), 336-342. **https://doi.org/10.1037/1528-3542.7.2.336**

Finch, C., & Cassell, E. (2006). The public health impact of injury during sport and active recreation. *Journal of Science and Medicine in Sport, 9*(6), 490-497. **https://doi.org/10.1016/j.jsams.2006.03.002**

Fortes, L. S., Lima-Junior, D., Barbosa, B. T., Faro, H. K., Ferreira, M. E., & Almeida, S. S. (2025). Effect of mental fatigue on decision-making skill and visual search behaviour in basketball players: an experimental and randomised study. *International Journal of Sport and Exercise Psychology, 23*(5), [Provide Page Range]. **https://doi.org/10.1080/1612197X.2022.2058055**

Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2009). Be smart, exercise your heart: Exercise effects on brain and cognition. *Nature Reviews Neuroscience, 9*(1), 58–65. **https://doi.org/10.1038/nrn2298**

Klusemann, M. J., Pyne, D. B., Hopkins, W. G., & Drinkwater, E. J. (2013). Activity profiles and demands of seasonal and tournament basketball competition. *International Journal of Sports Physiology and Performance, 8*(6), 623-629. **https://doi.org/10.1123/ijspp.8.6.623**

Lemoyne, J., Poulin, C., Richer, N., & Bussières, A. (2017). Analyzing injuries among university-level athletes: prevalence, patterns and risk factors. *The Journal of the Canadian Chiropractic Association, 61*(2), 88-96. [Search page range is a recommendation if is it missing the whole PDF file of the paper]

Lucia, S., Aydin, M., & Di Russo, F. (2023). Sex differences in cognitive-motor dual-task training effects and in brain processing of semi-elite basketball players. *Brain Sciences, 13*(3), 443. **https://doi.org/10.3390/brainsci13030443**

North, J. S., Williams, A. M., Hodges, N., Ward, P., & Ericsson, K. A. (2009). Perceiving patterns in dynamic action sequences: Investigating the processes underpinning stimulus recognition and anticipation skill. *Applied Cognitive Psychology, 21*(7), 886–902. **https://doi.org/10.1002/acp.1581**

OOgunmayowa, O. T. (2023). *Neighborhood historical redlining, present-day social vulnerability and sports and recreational injury hospitalizations in the United States* (Publication No. [Provide Number if it is a dissertitation, otherwize, remove it]). [Provide Repository for this thesis, otherwise remove whole line]

Pernigoni, M., Ferioli, D., Calleja-González, J., Sansone, P., Tessitore, A., Scanlan, A. T., & Conte, D. (2024). Match-related fatigue in basketball: A systematic review. *Journal of Sports Sciences, 42*(18), 1727-1758. **https://doi.org/10.1080/02640414.2024.2409555**

Rui, P., Ashman, J. J., & Akinseye, A. (2019). Emergency department visits for injuries sustained during sports and recreational activities by patients aged 5–24 years, 2010–2016. *[Provide Publication details.]*

Sansone, P., Fortes, L. S., Polverari, D., Leicht, A., & Gomez-Ruano, M. A. (2025). Subjective mental fatigue ratings are not associated with basketball game-related statistics during official semiprofessional male games. *Frontiers in Psychology, 16*, 1644762. **https://doi.org/10.3389/fpsyg.2025.1644762**

Scanlan, A. T., Dascombe, B. J., & Dalbo, V. J. (2011). A comparison of the activity demands of elite and sub-elite Australian men's basketball competition. *Journal of Sports Sciences, 32*(2), 170–178. **https://doi.org/10.1080/02640414.2011.582509**

Spielberger, C. D. (2021). Stress and anxiety in sports. In *Anxiety in sports* (pp. 3-17). [Please provide the complete information for the book in which this chapter appears. The chapter citation should include the editor's name, book title, and publisher.]

Sun, H., Soh, K. G., Roslan, S., Wazir, M. R. W. N., & Soh, K. L. (2021). Does mental fatigue affect skilled performance in athletes? A systematic review. *PloS one, 16*(10), e0258307. **https://doi.org/10.1371/journal.pone.0258307**

Tornero-Aguilera, J. F., Jimenez-Morcillo, J., Rubio-Zarapuz, A., & Clemente-Suárez, V. J. (2022). Central and Peripheral Fatigue in Physical Exercise Explained: A Narrative Review. *International Journal of Environmental Research and Public Health, 19*(7), 3909. **https://doi.org/10.3390/ijerph19073909**

Uttal, D. H., Meadow, N. G., Tipton, E., Hand, L. L., Alden, A. R., Warren, C., & Newcombe, N. S. (2013). The malleability of spatial skills: A meta-analysis of training studies. *Psychological Bulletin, 139*(2), 352–402. **https://doi.org/10.1037/a0028446**

Vesia, M., Esposito, J., Prime, S. L., & Klavora, P. (2008). Correlations of selected psychomotor and visuomotor tests with initial Dynavision performance. *Perceptual and Motor Skills, 107*(1), 14–20. **https://doi.org/10.2466/pms.107.1.14-20**

Wang, H., & Li, Z. (2021). Risk recognition and identification of sports activities in colleges and universities. *Journal of Intelligent & Fuzzy Systems, 40*(2), 3373-3383. **https://doi.org/10.3233/JIFS-189376**

Wells, A. J., Hoffman, J. R., Beyer, K. S., Hoffman, M. W., Jajtner, A. R., & Fukuda, D. H. (2014). Reliability of the Dynavision D2 for assessing reaction time performance. *Journal of Sports Sciences, 32*(6), 516–520. [Search for PMID, is recommendation]

Yuan, R., Sun, H., Soh, K. G., Mohammadi, A., Toumi, Z., & Zhang, Z. (2023). The effects of mental fatigue on sport-specific motor performance among team sport athletes: A systematic scoping review. *Frontiers in Psychology, 14*, 1143618. **https://doi.org/10.3389/fpsyg.2023.1143618.**

تأثير التعب المرتبط باللعبة على الأداء الإدراكي المعرفي لدى اللاعبين الجامعيين لكرة السلة الترفيهية: تقييم دينافيجين د2

الملخص :

هدفت الدراسة التعرف الى تأثير التعب الناتج عن مباريات كرة السلة التنافسية على الأداء الإدراكي-المعرفي لدى لاعبي كرة السلة الجامعيين من المستوى الترفيهي. شارك في الدراسة عشرون لاعب كرة سلة (10 إناث، متوسط العمر = 21 ± 1 سنة؛ 10 ذكور، متوسط العمر = 20 ± 2 سنة) خضعوا لاختبارات Dynavision™ D2 لقياس زمن الاستجابة البصرية والحركية، وعدد الضربات في المهام الاستباقية الوضع (A والتفاعلية) الوضع (B)، بالإضافة إلى متوسط زمن الاستجابة لكل ضربة قبل وبعد المباريات التنافسية. أظهرت اختبارات (ت) للعينات المزدوجة زيادة معنوية في زمن الاستجابة البصرية بعد المباراة لدى الإناث ($p < 0.05$)، ($d = 0.92$)، بينما لم تظهر هذه الزيادة لدى الذكور. كما انخفض عدد الضربات في الوضع Aبشكل معنوي بعد المباراة لدى كل من الذكور ($p < 0.05$) ($d = 0.73$)، والإناث($p < 0.05$) ($d = 0.72$)، في حين انخفض عدد الضربات في الوضع B بشكل معنوي فقط لدى الذكور ($p < 0.05$) ($d = 0.82$)، وكشفت نتائج تحليل التباين الثنائي (ANOVA) عن تفاعل معنوي بين الجنس والتعب على زمن الاستجابة البصرية، $F(1, 18) = 5.67$، $p < 0.05$، $\eta^2 = 0.24$. ، تشير هذه النتائج إلى وجود تأثيرات نوعية للجنس في استجابة الأداء الإدراكي-المعرفي للتعب، مما يبرز الحاجة إلى تدخلات مخصصة للحفاظ على القدرات الإدراكية-الحركية للرياضيين والحد من مخاطر الإصابات.

الكلمات المفتاحية: التعب، الأداء الإدراكي-المعرفي، كرة السلة؛،دينافيجين د2.