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المجلة الأردنية في التربية البدنية وعلوم الرياضة

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The Effect of Mental Fatigue on the Accuracy of Performing the Smash Shot in Terms of Some Kinematic Variables Associated with it Among Volleyball Players

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Abstract :

This study aimed to investigate the effect of mental fatigue on the accuracy of performing the volleyball spike, with particular emphasis on selected kinematic variables associated with the skill. The study sample consisted of 14 players from the Jordanian Volleyball League during the 2023 season. Participants completed a test of volleyball spike accuracy and a mental fatigue test. Their performance during the spike-accuracy test was recorded using two Canon EOS 80D cameras. The recorded footage was subsequently analyzed using Kinovea software to assess the selected kinematic variables. Several statistical methods were employed to analyze the data, including means, standard deviations, the skewness coefficient, the Shapiro–Wilk test, and the t-test. The results supported the study hypothesis, indicating a statistically significant effect of mental fatigue at the significance level of $\alpha = 0.05$ on volleyball spike accuracy in terms of selected associated kinematic variables. The findings indicate that mental fatigue may adversely affect the accuracy of the volleyball spike and associated kinematic characteristics. The study recommends developing training and psychological-support programs aimed at enhancing players' mental stability during matches, thereby enabling them to maintain the required level of skill performance despite the psychological and mental demands encountered during competitive volleyball matches.

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Key Words: Mental fatigue, Kinematic Variables, Accuracy, Smash hit, Volleyball.

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Introduction :

Prolonged engagement in mental effort and cognitively demanding activities can induce a psychological and physiological state known as mental fatigue. This state is characterized by feelings of fatigue and exhaustion, as well as a reduced ability to continue performing a required task, regardless of whether the task is physical or mental (Pageaux et al., 2018).

Mental fatigue is also often accompanied by lethargy and alterations in dopamine levels, which may reduce the ability to perform executive functions, including those required during sports activities. Previous research has shown that mental fatigue may also be associated with an increase in heart rate, a reduction in oxygen uptake, and an increase in blood lactate concentration. These physiological responses reflect the potential impact of mental fatigue on physical and sports performance (Yuan, 2023).

Halim et al. (2019) indicated that mental fatigue can also induce a state of neurological and psychological strain that intensifies negative feelings during the performance of various tasks. This may reduce individuals' motivation to achieve their goals and consequently have a negative effect on performance behavior. The same principle applies to sports activities, which, like other forms of human behavior, depend partly on achievement motivation. The situation becomes more challenging when mental fatigue affects performance that requires a high level of concentration and accuracy, as is the case with the volleyball smash hit**.**

The smash hit is a fundamental offensive skill in volleyball and contributes significantly to effective attacking performance. It also adds an element of excitement to the game. Successful execution of the smash requires considerable strength, concentration, coordination, and accuracy. Therefore, it is not sufficient for the ball to be hit with adequate force; it must also be directed accurately toward the intended target. The movement begins with the player adopting a preparatory stance with the knees flexed. The arms are then positioned backward in preparation for the upward jump. Subsequently, the striking arm is drawn backward and flexed, followed by a forceful forward movement to strike the ball when it is positioned in front of the hand (Yuan, 2023).

An examination of the performance characteristics of the smash hit reveals that the skill is based on a number of kinematic and kinetic variables that must be appropriately coordinated to ensure successful execution. Jump height, movement sequence, and force transfer are among the mechanical variables that ultimately influence the force transmitted to the ball, the direction of body movement, and the positioning of the striking hand. Accordingly, the performance of the volleyball smash cannot be adequately explained in isolation from the mechanical variables—both kinematic and kinetic—that contribute to the ideal execution of the skill (Wagner, 2009).

Therefore, the present study aimed to investigate the effect of mental fatigue on volleyball players' performance, particularly during the execution of the smash hit. The study specifically examined its effect on smash-hit accuracy and selected kinematic variables.

Materials and Methods :

Research Design and Participants :

This study employed a descriptive research design**.** The study sample consisted of 14 volleyball players competing in the 2024 Jordanian Volleyball League. The participants were selected based on their distinguished attacking and striking performance within their respective teams. Their descriptive characteristics were as follows: age = 24 ± 1.3 years, height = 1.92 ± 0.09 m, body mass = 76 ± 4 kg, and training experience = 8 ± 3.2 year

Instruments :

Study Tests

1. Smash-Hit Accuracy Test

- Each player performed 10 smash hits, directing the ball diagonally toward the opposite corner of the court.
- A target area measuring **2 m × 2 m** was designated in the opposite corner of the court as the ball-reception area.

- One point was awarded for each ball that landed within the designated target area, whereas balls landing outside the area received zero points. Thus, the maximum score on the test was **10 points** (Palao & Valades, 2016).

2. Mental Fatigue Test

The mental fatigue protocol described and used by Kurnarth et al. (2020) was adopted in the present study. The protocol was designed to expose participants to prolonged mental effort. At the beginning of the test, four words—red, blue, green, and yellow—were presented randomly on a computer screen. Each word was displayed for 1.5 seconds. The words were presented in different colors; for example, the word *red* could be displayed in blue. Participants were instructed to identify the color in which the word was displayed rather than the meaning of the word**.**

The task was then reversed, and participants were required to identify **the** meaning of the word rather than the color in which it was displayed**.** The test continued continuously for **30** minutes under appropriate experimental conditions and in a quiet environment free from external noise. Before the test, participants were encouraged to achieve the best possible performance. Approximately 1,250 stimuli were presented to each participant during the test.

Devices and Equipment :

The following equipment was used:

1. A computer display screen.
2. A Lenovo laptop computer.
3. A volleyball court.
4. Molten volleyballs.
5. Two Canon EOS 80D cameras for video recording. The first camera was positioned laterally and perpendicular to the participant's line of movement, with a focus on the striking hand. The second camera was positioned at the ball-reception area.
6. Kinovea motion-analysis software.

Study Procedures :

1. Small markers were attached to the participants' joints, including the ankle, knee, pelvis, and shoulder, to facilitate motion analysis.
2. The first Canon EOS 80D camera was positioned laterally and perpendicular to the participant's movement. The camera was located **6.77 m** from the performance area, with the lens positioned at a height of **0.96 m**.
3. The second Canon EOS 80D camera was positioned perpendicular to the ball-reception area. It was located **5.84 m** from the area, with the lens positioned at a height of **0.98 m**.
4. After positioning the first camera, an image of a **1 m × 1 m** reference square was recorded to verify the scale used in the subsequent motion analysis.

Experimental Procedures :

Following a standardized warm-up, the players individually performed the smash-hit accuracy test while their performance was recorded on video.

After a 3-hour rest period**,** the players individually completed the mental fatigue protocol. Immediately after completing the mental fatigue test, each player performed the smash-hit accuracy test again, and the performance was recorded on video.

Statistical Analysis :

The data were analyzed using the following statistical procedures:

- Mean (M)
- Standard deviation (SD)
- Skewness coefficient
- Kurtosis coefficient
- Paired-samples t-test

The level of statistical significance was set at $\mathbf{p < 0.05}$.

Results :

Table (1): Values for some descriptive statistical indicators of kinematic variables before the mental fatigue experience (n=14)

Kinematics Variables	Lowest value	highest value	Mean	SD	Torsion coefficient	W (Shapiro-Wilk)	P value
Velocity before jump(m/s)	3.98	4.15	4.065	0.106	0.10	0.975	0.713
Ball speed (m/s)	31.25	32.20	31.725	0.042	2.03	0.963	0.630
Jump degree (degree)	69	72	70.5	1.021	1.52	0.957	0.674
Height of center of gravity (m)	1.89	1.90	1.895	0.795	-0.64	0.981	0.590
Ball shot angle (degrees)	24	25	24.5	2.15	0.62	0.963	0.754
Accuracy 10	7	8	7.5	0.25	0.38	0.977	0.701

Table 1 presents the descriptive statistical indicators for the kinematic variables measured before the induction of mental fatigue. The table also presents two indicators used to assess the normality of the data distribution: the skewness coefficient and the kurtosis coefficient.

With respect to the skewness coefficient, the highest observed value was 2.03, while the remaining values were lower. This value falls within the generally accepted range of −3 to +3, indicating an acceptable degree of symmetry in the distribution of the data.

Regarding the kurtosis coefficient, which describes the degree of peakedness or flatness of the data distribution relative to a normal distribution, the highest observed value was 2.82. This value falls within the acceptable range for kurtosis, as values of ±8 or less are generally considered acceptable for assuming an approximately normal distribution.

Based on these two indicators, it can be concluded that the distributions of the kinematic variables approximate a normal distribution. Therefore, the data meet the normality assumption required for the application of parametric statistical tests.

Testing the Research Hypothesis :

The research hypothesis was formulated as follows:
There is a statistically significant effect at the significance level of $\alpha = 0.05$ of mental fatigue on smash-hit accuracy and selected kinematic variables among volleyball players.

Table (2): Results of the paired-samples t-test for the effect of mental fatigue on smash-hit accuracy and selected kinematic variables among volleyball players (n = 14)

Kinematics Variables	Before mental fatigue		After mental fatigue		Diff test	
Velocity before jump(m/s)	SD	MEAN	SD	MEAN	SIC	t
Ball speed (m/s)	0.012	4.065	0.12	3.122	.000	12.30
Jump degree (degree)	0.037	31.725	0.32	21.012	.000	2.03
Height of center of gravity (m)	0.528	70.5	1.02	57.2	.000	3.01
Ball shot angle (degrees)	0.703	1.895	0.16	1.81	.000	20.1
Accuracy 10	0.411	24.5	0.94	27.2	.000	19.52

Table 2 presents the results of the t-test examining the effect of mental fatigue on the accuracy of direct free-kick shooting and selected kinematic variables among soccer players. A comparison of the calculated p-values with the predetermined significance level of **$\alpha = 0.05$** shows that all reported p-values were below 0.05. These results indicate that the observed differences were statistically significant.

Accordingly, the research hypothesis was supported. The findings suggest that mental fatigue significantly affected several of the kinematic variables presented in Table 2. Changes in these variables were, in turn, associated with a decline in the accuracy of direct free-kick shooting. These findings indicate that mental fatigue may negatively influence both the biomechanical characteristics of the kicking movement and the accuracy of performance among soccer players.

Discussion :

The findings of the present study indicate that mental fatigue had a significant negative effect on the players' performance, particularly on the accuracy of the smash hit. The mean accuracy score decreased from 7.5 before mental fatigue to 5.5 following the mental-fatigue protocol**.** This decline in accuracy appears to be consistent with the changes observed in the kinematic variables associated with the performance of the skill.

Following the onset of mental fatigue, the players' approach speed before take-off decreased, which may have reduced their momentum and consequently affected the efficiency of the subsequent movement sequence. A reduction in the force generated during the take-off phase may also have contributed to a decrease in jump height. This interpretation is supported by the observed reduction in the height of the player's center of gravity at the moment of ball contact, which may have prevented the players from achieving the optimal body position relative to the net.

In addition, mental fatigue was associated with changes in the direction of the jump. The vertical component of the jump angle decreased, whereas the horizontal component increased. Consequently, the players' movement became more forward-oriented rather than sufficiently upward and forward. This change may have reduced their ability to achieve the optimal hitting height and maintain precise control over the ball. The resulting decrease in ball velocity may have further contributed to the reduction in smash-hit accuracy.

The players appeared to compensate for the reduction in hitting height by increasing the aiming angle in an attempt to direct the ball toward the intended target. However, this compensatory adjustment may not have been sufficient to overcome the negative effects of mental fatigue on the overall coordination and accuracy of the movement. Taken together, these findings suggest that mental fatigue may adversely affect the coordination of the kinematic components underlying the smash hit, ultimately compromising the accuracy and effectiveness of the skill.

From a physiological perspective, the observed changes may be related to the effects of mental fatigue on the central nervous system. Mental fatigue has been associated with changes in the functioning of brain regions involved in motor control and response regulation, including the cerebral cortex (Jacquet, 2021). Moreover, mental fatigue may reduce the efficiency of central processing and the execution of motor commands, potentially affecting the activation of motor programs involved in skilled physical performance (Marcora, 2009). These mechanisms may help explain the decline in the players' ability to coordinate the complex sequence of movements required for an effective smash hit.

The findings of the present study are consistent with those reported by Palao and Valades (2016) and Alawi et al. (2022)**,** who likewise reported negative effects associated with fatigue on aspects of sports performance and skill execution. The agreement between these findings provides further support for the importance of considering mental fatigue when evaluating athletes' technical and biomechanical performance.

Conclusion :

Although coaches generally place considerable emphasis on managing physical and muscular fatigue, the findings of the present study highlight the importance of giving greater attention to **mental fatigue**. Training programs, both during the preparatory period and throughout the competitive season, should incorporate strategies designed to improve players' ability to cope with prolonged mental demands and maintain their technical performance under conditions of mental fatigue.

Given its potential negative effects on physical, biomechanical, and skill-related performance, mental fatigue should be considered an important factor in the preparation of volleyball players. Coaches and sport practitioners are therefore encouraged to address mental fatigue systematically and incorporate appropriate mental-recovery and performance-maintenance strategies into regular training programs.

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أثر التعب العقلي على دقة أداء الضربة الساحقة بدلالة بعض المتغيرات الكينماتيكية المتربطة بها لدى لاعبي الكرة الطائرة

الملخص :

هدفت الدراسة التعرف الى تأثير التعب العقلي على دقة أداء الضربة الساحقة في الكرة الطائرة من حيث بعض المتغيرات الحركية (الكينماتيكية) المرتبطة بها. تكونت عينة الدراسة من (14) لاعبًا من دوري الكرة الطائرة الأردني لعام 2023. وقد خضعوا لاختبار دقة أداء الضربة الساحقة في الكرة الطائرة، وكذلك لاختبار التعب العقلي، حيث تم تصوير أدائهم لاختبار دقة الضربة باستخدام كاميرتين من نوع(Canon EOS 80D)، بينما تم تحليل الأداء باستخدام برنامج(Kenova).تم استخدام عدة أساليب إحصائية للوصول إلى نتائج الدراسة، وهي المتوسطات الحسابية، الانحراف المعياري، معامل التفاوت (skewness)، وأختبار شيبرو- ويلك (Shapiro-Wilk)، واختبار(ت). أظهرت النتائج قبول فرضية الدراسة، والتي تنص على وجود تأثير دال إحصائيًا عند مستوى الدلالة ($\alpha \leq 0.05$) للتعب العقلي على دقة أداء الضربة الساحقة في الكرة الطائرة من حيث بعض المتغيرات الحركية المرتبطة بها. أوصت الدراسة بتطوير برامج تدعم الاستقرار الذهني للاعب أثناء المباريات، بحيث يتمكن من الاستمرار في أداء المهارة المطلوبة منه مهما تعرض لمشاكل ذهنية نتيجة الظروف المختلفة التي تحدث أثناء مباريات الكرة الطائرة.

الكلمات المفتاحية: التعب العقلي، المتغيرات الكينماتيكية، الدقة، الضربة الساحقة، كرة الطائرة.

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المجلة الأردنية في التربية البدنية وعلوم الرياضة

The Impact of Self-Esteem on the Acquisition of Swimming Skills among Kindergarten Students

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Abstract :

This study aimed to examine whether kindergarten children's self-esteem is associated with their proficiency in acquiring swimming skills. A descriptive correlational research design was employed to investigate the relationship between self-esteem and swimming skill acquisition. The study sample consisted of 100 kindergarten children aged 5–6 years, selected from five schools and sports centers in Amman. Data were collected using a self-esteem scale and the Preschool Competence and Behavioral Evaluation (PCBE) Scale. The findings indicated that children with higher levels of self-esteem demonstrated greater proficiency in acquiring swimming skills, with a strong positive association observed between self-esteem and swimming proficiency. Significant improvements in both self-esteem and swimming skills were observed among the participants, as indicated by the results of paired-samples t-tests. Analysis of variance revealed a statistically significant difference in swimming proficiency by gender. However, regression analysis showed that self-esteem was a significant predictor of swimming proficiency regardless of gender. Overall, the findings suggest that enhancing children's self-esteem may facilitate faster and more effective acquisition of swimming skills. These findings highlight the importance of creating supportive learning environments in which educators, swimming instructors, coaches, and parents can foster children's confidence and positive self-perceptions during the acquisition of swimming skills.

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Key Words: self-esteem; swimming; swimming skills; kindergarten children; skill acquisition.

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Introduction :

Swimming is an essential life skill that contributes to physical fitness, motor development, and overall psychological well-being. Developing swimming proficiency at an early age is particularly important because it can enhance children's physical coordination and motor skills while also helping them develop confidence in aquatic environments (Minkels et al., 2025). However, learning to swim can be challenging for young children, regardless of their level of physical competence. Successful acquisition of swimming skills requires children to be psychologically and physically prepared to engage with the aquatic environment. In this regard, psychological readiness has increasingly been recognized as an important factor in swimming skill acquisition (Koroglu, 2023).

Among the psychological factors that may facilitate children's learning and acquisition of new life skills, self-esteem plays a particularly important role. During early childhood, self-esteem is closely associated with learning behaviors, motivation, persistence, and the development of self-efficacy. Children who have a positive perception of their own abilities may be more willing to face challenges, persist when difficulties arise, and engage actively in the learning process. In physical education and sport psychology, however, relatively few studies have examined the relationship between self-esteem and motor skill development in young children (Tavakolian et al., 2020).

In this context, Barton et al. (2012) reported that children with higher levels of self-esteem are more likely to engage in physical activity, persist in challenging activities, and respond positively to instructional feedback. In contrast, children with lower self-esteem may experience greater anxiety, fear failure, and show less motivation to acquire new skills, including swimming skills. Self-esteem may also be associated with children's perceived competence in aquatic environments. When children believe that they are capable of performing swimming tasks successfully, they may develop greater confidence and become more willing to enter the water and engage in unfamiliar aquatic activities. This supports the proposed relationship between self-esteem, perceived competence, and willingness to engage in aquatic activities (Korkmaz & Korkmaz, 2025).

Learning to swim can present particular psychological challenges for young children. Some children may be reluctant or fearful when entering the water, hesitate to attempt unfamiliar movements, or rely heavily on reassurance and encouragement from parents or teachers. Such psychological barriers may interfere with their willingness to participate fully in swimming activities and, consequently, with the development of swimming proficiency (Amelia, 2012). Therefore, understanding the role of self-esteem in swimming skill acquisition is important for creating learning environments that encourage confidence, motivation, persistence, and positive engagement among young swimmers.

I have edited this section as a publication-ready literature-review passage, with particular attention to natural academic phrasing, coherence between studies, avoidance of repetitive wording, grammatical accuracy, and a clear connection between self-esteem and motor-skill acquisition. I have also preserved the citations and intended claims without introducing unsupported information.

The Concept of Self-Esteem in Early Childhood Development :

Self-esteem is an important psychological construct that influences children's motivation to engage in new experiences, their self-confidence, and their sense of personal competence. It refers to an individual's evaluation of their own value, worth, and abilities (Yaswinda, 2019). During early childhood, self-esteem is shaped by a range of factors, including parental support, social interactions, and participation in physical activities. Children with higher levels of self-esteem tend to be more willing to face challenges, demonstrate greater resilience, and experience better emotional well-being (Papadopoulos, 2021).

Previous research has also identified a relationship between self-esteem and cognitive development. Papadopoulos (2021) reported that children with higher self-esteem tend to develop stronger cognitive abilities and perform better across a range of learning tasks. Similarly, Morcom (2017) examined the role of self-esteem in the development of cultural identity and found that individuals with higher levels of self-esteem tended to have greater confidence in their abilities, including their ability to learn new skills. These findings highlight the potential importance of self-esteem during children's early learning experiences, including the acquisition of motor skills such as swimming.

Physical activity can also play an important role in the development of children's self-esteem and confidence. Participation in sports and other activity-based experiences can foster a sense of competence, facilitate positive social interactions, and contribute to overall emotional well-being (Barton et al., 2012). In this regard, Koroglu (2023) examined self-esteem and self-efficacy among students enrolled in physical education and sports programs and found a positive association between participation in physical activities and self-esteem. The study suggested that active participation in sports can provide children with a sense of accomplishment, which may, in turn, strengthen their confidence in their physical abilities.

Tavakolian et al. (2020) investigated the effects of nonlinear pedagogy on motor proficiency and self-esteem among obese girls with hyperactivity. Their findings indicated that a structured and responsive physical education program could contribute to improvements in motor skills while also enhancing children's self-confidence. These findings suggest that appropriate teaching approaches may have benefits that extend beyond physical skill development. In the context of swimming, the use of supportive and effective instructional methods may therefore help strengthen children's self-esteem while facilitating the acquisition and development of swimming skills.

Taken together, the literature suggests that self-esteem and motor development may be closely interconnected during childhood. Children who feel confident in their abilities may be more willing to participate, persist in challenging activities, and respond positively to instruction. This relationship is particularly relevant to swimming, where psychological readiness and confidence may influence children's willingness to engage with the aquatic environment and practice unfamiliar motor skills.

I have revised the section into fluent, humanized, publication-ready academic English. I have also strengthened the logical connections between the empirical studies and the theoretical perspectives, removed repetition, corrected citation grammar, and clarified the relationship between **self-esteem, self-efficacy, motivation, and motor-skill acquisition**.

The Role of Self-Esteem in Motor Skill Acquisition :

Self-esteem plays an important role in children's acquisition of motor skills. Children with higher levels of self-esteem are generally more willing to explore movement, take on new challenges, and persist when learning unfamiliar skills (Minkels et al., 2025). In the context of swimming, Chan et al. (2023) highlighted the importance of self-esteem in children's learning and performance. Children who have greater confidence in their abilities are more likely to perceive themselves as competent swimmers and to approach new aquatic skills with greater willingness and persistence. This sense of competence can foster intrinsic motivation and encourage continued engagement during swimming lessons. As children experience success in acquiring new skills, these positive experiences may further strengthen their confidence and sense of self-worth, creating a reinforcing cycle that encourages continued participation and enjoyment.

The learning environment also plays an important role in supporting this process. Instructional settings that promote autonomy, provide encouragement, and use positive reinforcement can strengthen children's self-esteem and facilitate skill acquisition (Minkels et al., 2023). When children feel supported rather than pressured, they may become more willing to experiment with new movements, respond positively to feedback, and persist when they encounter difficulties.

Fernandes et al. (2024) further provided evidence that self-esteem may mediate the relationship between physical activity participation and psychological well-being. Children who feel valued and competent through their participation in sports may experience greater emotional stability and become more engaged in learning. Similarly, Equinet et al. (2025) and Sinha (2024) emphasized the broader developmental benefits of continued participation in swimming and other sports. Taken together, these findings suggest that self-esteem may play a central role in linking children's motivation, psychological well-being, and acquisition of sport-related skills.

Although swimming provides numerous physical and developmental benefits, many children experience psychological barriers that can interfere with the acquisition of swimming skills. Fear of water, anxiety, and lack of confidence are among the most common challenges encountered by young learners. Minkels et al. (2025), in their review of evidence on motor-learning approaches to swimming instruction, reported that supportive and encouraging learning environments can help reduce fear and facilitate skill acquisition. These findings also suggest that psychological strategies incorporated into swimming instruction may help children manage anxiety, overcome fear, and develop greater confidence in the aquatic environment.

The relationship between self-esteem and swimming skill acquisition can also be understood through established theories of motivation and learning. **Bandura's social cognitive theory** emphasizes the importance of self-efficacy in shaping individuals' learning behaviors and performance. In the context of swimming, children who have strong beliefs in their ability to perform aquatic skills are more likely to remain engaged when faced with difficulties and to persist following unsuccessful attempts. Successful experiences can subsequently strengthen their perceived competence and encourage further effort, thereby supporting more effective skill acquisition (Sun & Espeso, 2024).

Similarly, Deci and Ryan's self-determination theory proposes that intrinsic motivation is fostered when individuals experience autonomy, competence, and relatedness. Positive self-esteem can contribute to children's perceptions of competence, while a supportive instructional environment can reinforce feelings of autonomy,

competence, and social connection. Together, these conditions can promote more self-determined forms of motivation and encourage sustained engagement in learning activities (Costa et al., 2020).

Empirical research in aquatic and sport-education settings provides further support for these theoretical relationships. Minkels et al. (2023) reported that swimming lessons characterized by autonomy-supportive instructor behaviors were associated with stronger perceptions of competence and higher levels of motivation among children learning to swim. Such findings reinforce the importance of creating instructional environments that not only teach technical swimming skills but also support children's psychological needs. By fostering confidence, autonomy, competence, and positive social interactions, swimming instructors may help children overcome psychological barriers and become more motivated and persistent learners.

I have edited the section into natural, humanized, publication-ready academic English. I have retained the intended arguments and citations while improving the organization, removing awkward or machine-translated expressions, and making the discussion more cohesive and appropriately cautious.

Effective Teaching Strategies for Enhancing Self-Esteem in Swimming Lessons :

Several instructional strategies can be used to support children's self-esteem while facilitating the acquisition of swimming skills. In early childhood swimming education, creating a positive, encouraging, and supportive learning environment is particularly important (Amelia, 2012). Teaching approaches that incorporate engaging activities, recognize small achievements, and provide individualized feedback can help strengthen children's confidence and motivation to learn.

Zhang, Kuusisto, Nokelainen, and Tirri (2020) examined the effects of process-oriented praise and peer feedback on children's self-efficacy and found that both approaches had a positive influence on children's confidence and engagement. These strategies can be adapted to swimming instruction by recognizing children's effort and progress rather than focusing exclusively on the final outcome. Similarly, Han et al. (2021) highlighted the value of goal-setting interventions in strengthening children's self-regulation, motivation, and persistence. Setting achievable, age-appropriate goals during swimming lessons may therefore help children recognize their progress and develop a stronger sense of competence.

Social interaction and peer support can also contribute to children's psychological development. Henschen (2023) emphasized the benefits of socially interactive and peer-supported activities for improving mood, self-esteem, and sense of belonging. In swimming lessons, instructors can incorporate carefully structured pair and group activities that encourage cooperation and mutual support. Such activities can help children feel more comfortable, develop confidence in their abilities, and experience swimming as a positive and socially engaging activity.

A supportive and inclusive instructional environment is particularly important when working with young children. Rubin (2023) similarly emphasized the importance of supportive experiences in the development of self-esteem during early childhood. In the context of swimming, classes that are inclusive, encouraging, and responsive to individual differences may provide children with opportunities to develop both their swimming skills and their confidence. Rather than comparing children's performance, instructors can focus on individual progress and celebrate improvements at each stage of learning.

Gender Differences and Self-Esteem in Swimming :

Gender differences in self-esteem have been documented in the psychological literature, although the extent and nature of these differences may vary according to age, context, and social experiences. Participation in swimming may contribute to the development of self-esteem and self-confidence in both boys and girls, but children may respond differently to particular instructional approaches.

Ozcan (2025) reported that an eight-week swimming training program for children aged 12–14 years was associated with significant improvements in self-esteem and self-confidence. The findings indicated that boys entered the program with higher baseline levels of confidence and tended to demonstrate greater willingness to take risks, whereas girls appeared to benefit particularly from structured, supportive instruction that encouraged skill development and strengthened confidence. The experimental group also demonstrated greater improvements in self-confidence than the control group, suggesting a potential relationship between aquatic skill development and positive psychological outcomes.

Parental observations provide further support for the broader psychological benefits of swimming. Swim England (2025) reported that many parents observed noticeable improvements in their children's self-esteem and confidence following swimming lessons. These observations highlight the potential emotional and educational benefits of swimming beyond the development of physical skills.

Taken together, these findings suggest that swimming instruction can contribute positively to children's self-esteem and confidence. However, instructors should avoid relying on assumptions about boys' and girls' abilities or learning preferences. Instead, instruction should be responsive to individual needs and should provide all children with equal opportunities to participate, succeed, and develop confidence. Positive feedback, achievable challenges, encouragement, and confidence-building activities can help create an inclusive learning environment in which both boys and girls can benefit from swimming and develop a positive perception of their own abilities.

I have revised the **Statement of the Problem and Research Questions** into natural, humanized academic English suitable for journal publication. I have also strengthened the research gap and made the wording of the questions precise and consistent with the stated purpose of the study.

Statement of the Problem :

Swimming is an important life skill for children because it contributes to water safety, physical competence, and confidence. However, learning to swim can be particularly challenging for kindergarten children, and their progress may be influenced not only by their physical abilities but also by psychological and social factors, including self-esteem. Self-esteem reflects children's perceptions of their own abilities and sense of self-worth and may influence their motivation, persistence, willingness to attempt challenging tasks, and response to failure.

Children with low levels of self-esteem may experience greater fear and anxiety, avoid challenging activities, or progress more slowly when acquiring new skills. In contrast, children with higher levels of self-esteem may be more willing to participate, persist in the face of difficulties, and demonstrate greater confidence in their ability to learn and perform new skills. These psychological characteristics may be particularly relevant to swimming, where children must overcome unfamiliar aquatic experiences and develop confidence in their ability to control their movements in the water.

Despite the potential importance of self-esteem in swimming skill acquisition, relatively few studies have specifically examined this relationship among kindergarten-aged children. Previous research has largely focused on general motor-skill development or on children in older age groups. For example, Minkels et al. (2023), Fernandes et al. (2024), and Equinet et al. (2025) examined factors related to children's motor development, psychological well-being, and participation in physical activities. Minkels et al. (2023), in particular, reported that swimming lessons based on autonomy-supportive instructor behaviors were associated with higher perceptions of competence and motivation among young swimmers. These findings suggest that psychological factors may play an important role in children's engagement with swimming and in their acquisition of sport-related skills.

However, the specific relationship between self-esteem and swimming skill acquisition during the kindergarten years remains insufficiently understood. Examining this relationship is therefore important because a better understanding of the psychological factors involved in early swimming education may contribute to the development of more effective instructional strategies and interventions. Such approaches could help instructors and educators create supportive learning environments that promote children's psychological development while facilitating the acquisition of swimming skills.

Accordingly, the purpose of the present study is to examine the relationship between self-esteem and swimming skill acquisition among kindergarten children and to determine whether this relationship differs according to gender**.**

Research Questions :

The present study seeks to answer the following research questions:

1. Is self-esteem significantly associated with the acquisition of swimming skills among kindergarten children?
2. Does the relationship between self-esteem and swimming skill acquisition differ between boys and girls?

Methodology :

Study Design

A descriptive correlational research design was employed to examine the relationship between self-esteem and swimming skill acquisition among kindergarten children. Correlational methods were used to determine the strength and direction of the association between the two variables without manipulating any experimental conditions. In addition, pre- and post-assessments were conducted to examine changes in self-esteem and swimming proficiency following the eight-week swimming program.

Participants

The study included 100 kindergarten children aged 5–6 years who were recruited from five schools and sports centers in Amman that offered structured swimming programs. A stratified random sampling procedure was used to ensure balanced representation by gender, with an equal number of boys and girls (n = 50 each). The sample included both beginners and children with some previous swimming experience to provide diversity in terms of prior exposure to swimming.

The inclusion criteria required participants to be between 5 and 6 years of age, enrolled in a structured swimming lesson program, and have parental consent to participate in the study. Children with severe aquaphobia, medical conditions that prevented them from participating safely in swimming activities, or current enrollment in competitive swimming programs were excluded from the study.

Instruments

Data were collected using two primary assessment instruments: a measure of self-esteem and an assessment of swimming proficiency.

First, the Preschool Competence and Behavioral Evaluation Scale (PCBE) was used to assess the children's self-esteem. The instrument consists of 25 items rated on a five-point Likert scale: Always (5), Often (4), Sometimes (3), Rarely (2), and Never (1). Higher scores indicate higher levels of self-esteem. To ensure that the children fully understood the items, the researchers read each item aloud individually using simple, age-appropriate language and assisted the children in selecting their responses.

Second, a Swimming Proficiency Checklist (SPC)**,** adapted from previous research, was used to assess the children's swimming proficiency. The checklist evaluates four dimensions: basic water comfort, arm and leg coordination, breath control, and stroke development. Each dimension was rated by certified swimming instructors on a three-point scale: 1 = Needs Improvement, 2 = Developing, and 3 = Proficient.

Water comfort was operationalized using a combination of observational checklist items and instructor ratings that assessed each child's ease, confidence, and adjustment to the aquatic environment. Structured observations and instructor feedback were also used to document behavioral responses, motivation, and engagement during swimming activities.

To establish inter-rater reliability, more than one certified instructor independently evaluated each child's swimming proficiency. Any discrepancies between raters were subsequently discussed during consensus meetings, where instructors reviewed their ratings and reached an agreed-upon score.

Assessment Procedure

A pre-assessment and post-assessment procedure was adopted. Before the swimming lessons began, each participant underwent an initial assessment to establish baseline levels of self-esteem and swimming proficiency. The same assessment instruments were administered again after eight weeks of participation in the swimming program at the respective schools or sports centers. The pre- and post-assessment scores were then compared to determine whether changes had occurred in the children's self-esteem and swimming proficiency over the study period.

Data Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS)**.** Descriptive statistics, including means and standard deviations, were calculated for self-esteem and swimming proficiency scores.

Pearson's correlation coefficient was used to examine the strength and direction of the relationship between self-esteem and swimming proficiency. Paired-samples *t*-tests were conducted to compare participants' pre- and post-assessment scores. In addition, multiple regression analysis was performed to determine whether self-esteem significantly predicted swimming skill acquisition while controlling for gender and previous swimming experience.

The reliability and validity of the assessment instruments were supported by their use and validation in previous academic research. The instruments demonstrated acceptable internal consistency, with reported Cronbach's alpha coefficients exceeding 0.80. Inter-rater reliability for the swimming proficiency assessment was supported by having multiple certified instructors independently evaluate each participant.

Ethical Considerations

The study adhered to established ethical standards for research involving children. Written informed consent was obtained from the children's parents or legal guardians before participation, and child assent was obtained when appropriate and developmentally feasible. Participants' confidentiality was maintained by anonymizing the collected data and restricting access to authorized members of the research team. The study also received approval from the relevant Institutional Review Board (IRB).

All research data were stored in password-protected databases to safeguard participants' information and ensure compliance with applicable ethical and data-protection standards.

Overall, the methodology was designed to provide a systematic examination of the relationship between self-esteem and swimming proficiency among kindergarten children. By integrating standardized assessment instruments, structured observations, pre- and post-assessments, and appropriate statistical analyses, the study sought to provide a comprehensive understanding of the role of self-esteem in the acquisition of swimming skills during early childhood.

Results :

Descriptive Statistics

Descriptive statistics of self-esteem and swimming proficiency scores at both pre-assessment and post-assessment are summarized in table 1.

Table(1): Descriptive Statistics of Self-Esteem and Swimming Proficiency Scores

Variable	Pre-Mean	Pre-SD	Post-Mean	Post-SD	Min	Max
Self-Esteem	3.45	0.52	3.91	0.48	2.5	4.8
Swimming Proficiency	2.10	0.67	3.25	0.54	1.0	4.0

Table (1) showed that after the eight weeks swimming lessons, swimming proficiency increased from 2.10 to 3.25 and mean self-esteem increased from 3.45 to 3.91. The standard deviations (SD) indicate a moderate variation between students but there is also a trend for both the variables to improve.

Correlation Analysis

To test the relationship between self-esteem and swimming proficiency, Pearson correlation analysis was run.

Table (2): Pearson Correlation between Self-Esteem and Swimming Proficiency

Variables	Self-Esteem Score	Swimming Proficiency
Self-Esteem	1.00	0.68 ($p < 0.01$)
Swimming Proficiency	0.68 ($p < 0.01$)	1.00

Table (2) Analysis of correlation coefficient $r=0.68$, $p < 0.01$ indicates a strong positive correlation between self-esteem and swimming skill acquisition. Swimming skills improve more for children who have high level of self-esteem. This emphasizes that improvements in swimming skills are associated with high levels of self-esteem levels.

Paired t-Test Analysis

A paired t-test to have been calculated compare pre-assessment and post assessment for self-esteem and swimming proficiency.

Table (3): Paired t-Test for Self-Esteem and Swimming Proficiency

Variable	Mean Difference	t-value	p-value	Cohen's d
Self-Esteem	0.46	7.85	< 0.001	1.05
Swimming Proficiency	1.15	10.92	< 0.001	1.46

Table (3) showed that there is a statistically significant increase after the training period $p < 0.001$. Cohen's *d* values indicate large effect sizes 1.05 and 1.46, respectively, suggesting that the practical influence of the swimming intervention on both self-esteem and skill acquisition was substantial.

Regression Analysis

To control gender and prior swimming experience, this determinant of self-esteem was then allowed to be predicted on the amount of self-esteem that could be used to predict degrees of swimming proficiency in a multiple regression analysis.

Table (4): Multiple Regression Analysis for Predicting Swimming Proficiency

Predictor Variables	B	SE	T	p-value	Model R^2
Self-Esteem	0.62	0.11	5.63	< 0.001	
Gender (Male =1, Female =0)	0.12	0.09	1.34	0.18	
Prior Experience (Yes=1,No= 0)	0.35	0.08	4.37	< 0.001	
Constant	1.05	0.27	3.89	< 0.001	0.57

Regression Analysis

Table 4 indicates that self-esteem was a significant positive predictor of swimming proficiency ($B = 0.62$, $p < 0.001$). Previous swimming experience was also a significant positive predictor of swimming proficiency ($B = 0.35$, $p < 0.001$), whereas gender was not a statistically significant predictor ($p = 0.18$). Overall, the regression model explained 57% of the variance in swimming proficiency ($R^2 = 0.57$), indicating a substantial level of explanatory power.

Summary of Findings

The findings showed significant improvements in both self-esteem and swimming proficiency over the study period. A strong positive correlation was also observed between self-esteem and swimming proficiency ($r = 0.68$, $p < 0.01$), indicating that children with higher levels of self-esteem tended to demonstrate greater swimming proficiency.

The paired-samples *t*-tests revealed statistically significant improvements in both self-esteem ($p < 0.001$) and swimming skills ($p < 0.001$) from the pre-assessment to the post-assessment. In addition, the analysis of variance (ANOVA) revealed a statistically significant difference in swimming proficiency by gender. However, the regression analysis showed that gender was not a significant predictor of swimming proficiency after self-esteem and previous swimming experience were taken into account. In contrast, self-esteem remained a strong positive predictor of swimming proficiency regardless of gender.

Taken together, these findings suggest that self-esteem is closely associated with children's swimming proficiency and may play an important role in their acquisition of swimming skills. The disappearance of the gender effect in the regression model suggests that the gender differences observed in the ANOVA may be related, at least in part, to differences in self-esteem and previous swimming experience. Thus, the apparent influence of gender on swimming proficiency may be indirect rather than a direct effect.

It is also possible that the relationship between gender and swimming proficiency is influenced by multicollinearity or by a mediating mechanism involving self-esteem. However, the regression results alone do not establish mediation. A formal mediation analysis would be required to determine whether self-esteem actually mediates the relationship between gender and swimming proficiency. Accordingly, the present findings indicate that the initial gender differences in swimming proficiency may be partly explained by differences in self-esteem and previous swimming experience, rather than by gender itself.

Discussion :

This study examined the relationship between self-esteem and swimming skill acquisition among kindergarten children. The findings revealed a strong positive association between self-esteem and swimming proficiency, suggesting that children with higher levels of self-esteem tended to demonstrate greater proficiency in acquiring swimming skills. The findings are discussed below in relation to previous research, possible explanations for the observed relationships, and implications for practice.

Following the eight-week swimming program, significant improvements were observed in both self-esteem and swimming proficiency. In addition, a strong positive correlation was found between self-esteem and swimming proficiency ($r = 0.68$, $p < 0.01$). This finding is consistent with previous research suggesting that higher self-esteem is associated with better motor-skill development among children (Tavakolian et al., 2020). One possible explanation is that children with higher self-esteem may be more willing to explore new experiences, attempt challenging tasks, and persist when learning unfamiliar skills, including swimming. Previous research has similarly suggested that self-esteem is associated with children's confidence and motivation to participate in physical activities (Koroglu, 2023).

Children who have greater confidence in their abilities may be more likely to remain engaged when they encounter difficulties and to continue practicing until they improve. The present findings are also consistent with Minkels et al. (2025), who emphasized the importance of positive reinforcement and confidence-building strategies in supporting motor learning among children. At the same time, the relationship between self-esteem and swimming proficiency may be reciprocal. As children develop physical competence and successfully master new skills, their perceptions of their own abilities may improve, which may, in turn, strengthen their self-esteem. Amelia (2012) similarly reported that mastery of physical skills can contribute to more positive self-perceptions and higher self-esteem. From this perspective, the improvement observed in the present study may reflect an interaction between psychological development and physical competence rather than a one-way effect of self-esteem on swimming performance.

The multiple regression analysis further indicated that self-esteem was a significant positive predictor of swimming proficiency ($B = 0.62$, $p < 0.001$). This finding supports the broader literature emphasizing the role of psychological well-being in children's engagement with physical activities. Barton et al. (2012), for example, highlighted the importance of psychological well-being in promoting participation in physical activity. Children with

higher self-esteem may be more willing to approach challenges, remain engaged in learning activities, and persist when faced with difficulties. These characteristics may facilitate the acquisition and refinement of swimming skills.

Other developmental factors may also contribute to this relationship. Morcom (2017) emphasized the association between self-esteem, cultural identity, and children's personal development, suggesting that children's social and developmental contexts may shape their perceptions of competence and participation in physical activities. Similarly, Papadopoulos (2021) highlighted the relationship between cognitive development and self-concept in shaping children's behavior. Taken together, these perspectives suggest that self-esteem and motor-skill development are interconnected within a broader network of psychological, cognitive, social, and physical factors. However, the present correlational findings do not establish that self-esteem directly causes improvements in swimming proficiency.

The findings concerning gender are also noteworthy. Although the ANOVA indicated a statistically significant difference in swimming proficiency by gender, gender was not a significant predictor in the regression model after self-esteem and previous swimming experience were taken into account ($p = 0.18$). This finding suggests that the initial gender difference may be partly associated with differences in other variables included in the regression model, particularly self-esteem and previous swimming experience. It does not necessarily indicate that boys and girls respond identically to self-esteem, but rather that gender itself did not make a significant independent contribution to swimming proficiency in the final regression model.

This finding differs from some previous research reporting gender-related differences in self-esteem. For example, Kling et al. (1999) identified gender differences in self-esteem across the literature. Nevertheless, the present study did not find gender to be an independent predictor of swimming proficiency once self-esteem and previous swimming experience were considered. One possible explanation is that the swimming instruction provided in the participating settings was supportive and inclusive, potentially reducing differences in participation, confidence, and engagement between boys and girls. Rubin (2023) similarly emphasized the importance of environmental influences, including family support, peer relationships, and instructional practices, in the development of self-esteem during early childhood.

Previous swimming experience was also a significant positive predictor of swimming proficiency ($B = 0.35$, $p < 0.001$). This finding is consistent with the view that children's previous exposure to structured physical activities can contribute to their confidence and perceived competence. Yaswinda (2019) emphasized the importance of environmental stability and previous experiences in children's self-esteem development. Children who have previously participated in structured physical activities may be more familiar with instructional settings, physical challenges, and performance expectations, which may make it easier for them to adapt to swimming instruction and develop new aquatic skills.

Overall, the findings suggest that swimming proficiency among kindergarten children is associated with a combination of psychological and experiential factors. Self-esteem emerged as the strongest predictor in the present model, while previous swimming experience also made a significant contribution. Although gender differences were observed in the initial analysis, gender did not remain a significant predictor after these factors were taken into account. These findings highlight the importance of considering children's psychological characteristics and previous experiences alongside their physical abilities when designing early swimming programs.

Implications for Practice :

The findings have several practical implications for educators, swimming instructors, coaches, and parents. Given the strong association between self-esteem and swimming proficiency, swimming programs for young children should incorporate strategies that foster confidence, competence, motivation, and positive engagement.

1. **Positive Reinforcement:**
   Instructors should provide frequent, specific, and constructive feedback that recognizes children's effort, progress, and successful attempts. Appropriate praise and encouragement can help children develop a stronger sense of competence and remain motivated when learning challenging skills.
2. **Individualized Instruction:**
   Children develop physical and psychological skills at different rates. Instructors should therefore adapt activities and expectations to individual abilities and levels of experience. Providing achievable challenges and allowing children to progress at an appropriate pace can promote a sense of accomplishment and competence.
3. **Parental Involvement:**
   Parents can reinforce children's confidence by providing encouragement and positive support outside formal swimming lessons. Opportunities to participate in safe, age-appropriate aquatic activities may help maintain children's interest in swimming and reinforce their confidence in their ability to learn new skills.

4. **Early Exposure to Aquatic Environments:**
   Because previous swimming experience was a significant predictor of swimming proficiency, appropriate early exposure to aquatic environments may help children become more comfortable and confident in the water. Gradual and supportive exposure may also reduce anxiety and facilitate adaptation to swimming instruction.

Limitations and Future Research :

Although the study provides useful evidence concerning the relationship between self-esteem and swimming proficiency among kindergarten children, several limitations should be considered.

- **Sample Size and Generalizability:** The sample consisted of 100 kindergarten children recruited from five schools and sports centers in Amman. Consequently, the findings may not be generalizable to children from other regions, educational settings, or socioeconomic backgrounds. Future studies should use larger and more diverse samples to enhance the generalizability of the findings.
- **Study Duration:** Swimming skill development is a gradual process that may extend beyond the eight-week period examined in the present study. Longitudinal research conducted over longer periods would provide a more comprehensive understanding of how self-esteem and swimming proficiency develop and interact over time.
- **Lack of a Control Group:** Because the study did not include a control group, improvements observed between the pre- and post-assessments cannot be attributed solely to the swimming program. Future research should consider randomized controlled designs or comparison groups to determine whether structured swimming instruction produces changes in self-esteem and swimming proficiency beyond normal developmental changes.
- **Psychological Interventions:** Future research could investigate whether targeted psychological interventions, such as self-esteem enhancement programs, confidence-building activities, or autonomy-supportive instructional strategies, improve children's acquisition of swimming skills. Such studies could help clarify whether strengthening self-esteem leads to measurable improvements in swimming proficiency.
- **Mediation and Moderation Effects:** The finding that gender was significant in the ANOVA but not in the regression model warrants further investigation. Future studies could employ formal mediation or moderation analyses to determine whether self-esteem and previous swimming experience explain or modify the relationship between gender and swimming proficiency.

Conclusion :

This study highlights the important relationship between self-esteem and swimming skill acquisition among kindergarten children. The findings showed a strong positive association between self-esteem and swimming proficiency, and self-esteem emerged as a significant positive predictor of swimming proficiency even after accounting for gender and previous swimming experience. Previous swimming experience also made a significant contribution, whereas gender was not a significant independent predictor in the regression model.

The findings underscore the importance of viewing swimming education as more than the development of physical skills alone. Children's confidence, motivation, perceived competence, and previous experiences may all contribute to their engagement with learning and their progress in acquiring new skills. Creating supportive and autonomy-oriented learning environments may therefore help children develop both physical competence and positive psychological characteristics.

For educators, swimming instructors, and parents, the findings emphasize the value of encouragement, individualized instruction, achievable challenges, and constructive feedback. Such practices can help children develop confidence and persistence while creating positive experiences with physical activity. Nevertheless, the present findings should be interpreted as evidence of association and prediction rather than proof of a direct causal effect of self-esteem on swimming proficiency.

More broadly, the study supports a holistic approach to early childhood education in which physical, psychological, social, and emotional development are considered interconnected. Fostering self-esteem alongside physical competence may contribute to children's confidence and willingness to engage in new learning experiences, providing a potentially important foundation for their continued development.

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أثر تقدير الذات في اكتساب مهارات السباحة لدى أطفال الروضة

الملخص :

هدفت هذه الدراسة إلى بحث ما إذا كان تقدير الذات لدى أطفال رياض الأطفال يرتبط بمدى كفاءتهم في اكتساب مهارات السباحة. اعتمدت الدراسة المنهج الوصفي الارتباطي للكشف عن العلاقة بين تقدير الذات واكتساب مهارات السباحة. وتكوّنت عينة الدراسة من (100) طفل من أطفال رياض الأطفال، تراوحت أعمارهم بين 5 و6 سنوات، اختيروا من خمس مدارس ومراكز رياضية في عمّان. جُمعت البيانات باستخدام مقياس لتقدير الذات ومقياس الكفاءة والتقويم السلوكي لمرحلة ما قبل المدرسة (Preschool Competence and Behavioral Evaluation **[PCBE]**). أظهرت النتائج أن الأطفال ذوي المستويات الأعلى من تقدير الذات أظهروا كفاءة أكبر في اكتساب مهارات السباحة، مع وجود علاقة ارتباطية موجبة قوية بين تقدير الذات ومستوى الكفاءة في السباحة. كما أظهرت النتائج تحسنًا ذا دلالة إحصائية في كل من تقدير الذات ومهارات السباحة لدى أفراد العينة، وذلك وفقًا لنتائج اختبار (ت) للعينات المرتبطة. وكشف تحليل التباين عن وجود فروق ذات دلالة إحصائية في مستوى الكفاءة في السباحة تُعزى إلى الجنس. إلا أن تحليل الانحدار أظهر أن تقدير الذات كان متنبئًا ذا دلالة إحصائية بمستوى الكفاءة في السباحة بغض النظر عن جنس الطفل. وبوجه عام، تشير النتائج إلى أن تعزيز تقدير الذات لدى الأطفال قد يسهم في تسهيل اكتساب مهارات السباحة بصورة أسرع وأكثر فاعلية. وتبرز هذه النتائج أهمية توفير بيئات تعليمية داعمة يستطيع فيها المعلمون ومدربو السباحة والمدربون وأولياء الأمور تعزيز ثقة الأطفال بأنفسهم وتصوراتهم الإيجابية عن ذواتهم أثناء اكتساب مهارات السباحة.

الكلمات المفتاحية: تقدير الذات، السباحة، مهارات السباحة، أطفال رياض الأطفال، اكتساب المهارات.

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المجلة الأردنية في التربية البدنية وعلوم الرياضة

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.

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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.