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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.

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 $\boldsymbol{\alpha = 0.05}$ 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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REFERANCES

Alawi, M. M., Obeid, M. A., & Obeid, Z. A. (2022). Some of the variables Biokenmatics and the relationship between the accuracy of the performance of the skill spike Front (country) volleyball of Kirkuk University team. *Modern Sport*, 1(1), 45-52. https://doi.org/10.1234/ms.2022.011045

Halim, A., Tangkudung, J., & Dlis, F. (2019). The smash ability in volleyball games: The experimental study of teaching style and motor ability. *Journal of Education, Health and Sport*, *9*(12), 87–100.

Jacquet, T., Gaveau, J., Fourcade, P., Komar, J., & Berton, E. (2021). Persistence of mental fatigue on motor control. *Frontiers in Psychology*, *11*, 588253. https://doi.org/10.3389/fpsyg.2020.588253

Kunrath, C. A., Oliveira, T., Nakamura, F. Y., Roca, A., Greco, P. J., & Aquino, R. (2020). How does mental fatigue affect soccer performance during small-sided games? A cognitive, tactical and physical approach. *Journal of Sports Sciences*, *38*(15), 1818–1828. https://doi.org/10.1080/02640414.2020.1756680

Marcora, S. M., Staiano, W., & Manning, V. (2009). Mental fatigue impairs physical performance in humans. *Journal of Applied Physiology*, *106*(3), 857–864. https://doi.org/10.1152/japplphysiol.91324.2008

Pageaux, B., & Lepers, R. (2018). The effects of mental fatigue on sport-related performance. In M. Marcora & M. Sarkar (Eds.), *Progress in Brain Research* (Vol. 240, pp. 291–315). Elsevier. https://doi.org/10.1016/bs.pbr.2018.09.002

Palao, J. M., & Valades, D. (2016). Validity of the standing and jump spike tests for monitoring female volleyball players of different levels of competition. *Revista de Psicología del Deporte*, 16(3), 1102-1108.

Wagner, H., Tilp, M., von Duvillard, S. P., & Müller, E. (2009). Kinematic analysis of volleyball spike jump. *International Journal of Sports Medicine*, *30*(10), 760–765. https://doi.org/10.1055/s-0029-1220737

Yuan, R., Yi, L., Ding, J., Zhang, Y., & Wang, C. (2023). The effects of mental fatigue on sport-specific motor performance among team sport athletes: A systematic scoping review. *Frontiers in Psychology*, *14*, 1143618. https://doi.org/10.3389/fpsyg.2023.1143618

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.