International Journal of Sport Studies for Health

Journal Homepage

The Impact of Performance Fatigue on Visual Perception, Concentration, and Reaction Time in Professional Female Volleyball Players

Fariba Valaei[1], Jaleh Bagherli[1*], Morteza Taheri[2]

[1] Department of Motor Behavior, Ka.C, Islamic Azad University, Karaj, Iran
[2] Professor, Department of Behavioral and Cognitive sciences in Sport, Faculty of Sport Sciences, University of Tehran, Tehran, Iran

*** Corresponding author email address**: 0937846058@iau.ir

A r t i c l e I n f o

Article type:
Original Paper

How to cite this article:
Valaei, F., Bagherli, Z., & Taheri, M. (2024). The Impact of Performance Fatigue on Visual Perception, Concentration, and Reaction Time in Professional Female Volleyball Players. *International Journal of Sport Studies for Health, 7*(2), 47-54.
http://dx.doi.org/10.61838/kman.intjssh.7.2.5

A B S T R A C T

Objective: This study aimed to investigate the impact of performance fatigue on visual perception, concentration, and reaction time among professional female volleyball players.

Methods and Materials: The study population consisted of all professional female volleyball players in Qazvin province, with a purposive sampling method employed. A total of 24 eligible volleyball players were voluntarily selected and randomly divided into experimental and control groups. Variables such as visual perception, concentration, and reaction time were assessed as psychomotor variables. The Universal Viena test battery was used to measure these variables. The Shaw training method was employed in the study to induce performance fatigue. Factorial analysis of variance was utilized for data analysis.

Results: The findings indicated that performance fatigue significantly affected the components of visual perception, concentration, and reaction time in professional female volleyball players ($p \leq 0.05$).

Conclusion: As observed, fatigue can cause disturbances in psychomotor components such as visual perception, concentration, and reaction time. Therefore, it is essential that training under fatigue conditions be considered by coaches to enhance the psychomotor capacities of athletes.

Keywords: *Performance fatigue, visual perception, concentration, reaction time, professional volleyball players*

1. Introduction

Visual perception plays a pivotal role in volleyball, a sport demanding rapid and accurate interpretation of visual stimuli to execute skilled movements effectively. The ability to process and react to a fast-moving ball or opponent's actions is crucial for competitive success. Research has shown that fatigue can impair visual processing speed and accuracy, leading to decreased performance in tasks requiring visual discrimination and tracking (1, 2). Additionally, studies like those by Honda, Chang, and Kim (2018) have emphasized the importance of vision training in enhancing not only performance but also safety in sports, reducing the risk of concussions through improved reaction times and neck musculature strength (3).

Concentration, or the ability to maintain focus on relevant cues while filtering out distractions, is essential in volleyball, where split-second decisions can determine the outcome of

Article history:
Received 28 January 2024
Revised 12 March 2024
Accepted 21 March 2024
Published online 01 April 2024

a game (4, 5). Trecroci et al. (2021) discuss how cognitive functions, including concentration, are integral to sports-specific physical performance. They found that cognitive decline due to physical or mental fatigue could directly impact an athlete's ability to perform well in sports that require high levels of strategic thinking and coordination (6). The influence of fatigue on cognitive performance has also been examined in contexts like neurological recovery, where fatigue is shown to significantly affect cognitive efficiency (7).

Reaction time is another critical factor in volleyball, where players must quickly respond to opponents' serves and shots. Fatigue, both acute and chronic, can lengthen reaction times, thus impairing performance (8). Research by Zwierko et al. (2022) on young volleyball players highlights how fatigue can affect reaction time and the subsequent execution of complex movements (8). Furthermore, Enoka and Duchateau (2016) provide evidence that fatigue can translate into deteriorated human performance, particularly through delayed neural responses and reduced motor output (1).

Physiologically, fatigue manifests through the depletion of energy stores and the accumulation of metabolic byproducts, leading to decreased muscle power and endurance (9). Psychologically, fatigue can lead to decreased motivation and increased perception of effort, which can significantly impact an athlete's willingness and ability to perform at their best (10). These aspects underscore the complex nature of fatigue as it not only hinders physical capabilities but also challenges the mental resilience of athletes. Understanding the multifaceted effects of fatigue is crucial for designing effective training and recovery programs. Monitoring training load to optimize performance and minimize the risk of fatigue-related decline is critical (9). Implementing strategies like adequate rest, nutrition, psychological support, and perhaps most importantly, tailored training regimens that account for individual responses to fatigue, can help mitigate its adverse effects on performance.

The phenomenon of fatigue in volleyball has been studied from various physiological, psychological, and performance perspectives (11, 12). The complexity of volleyball, which requires quick reflexes, agility, and strategic thinking, makes understanding the impact of fatigue particularly crucial. According to Halson (2014), fatigue results from acute and chronic loads imposed by training and competition, which necessitates sophisticated monitoring to optimize athlete performance and health (9).

Physiological responses to fatigue, such as muscle soreness, reduced energy levels, and impaired motor function, directly affect an athlete's ability to perform high-intensity activities (11). This is particularly relevant in volleyball, where explosive movements like jumping and quick directional changes are frequent. Studies by Hadžić et al. (2014) further highlight how physical asymmetries, which can be exacerbated by fatigue, may affect the strength and performance of elite volleyball players, potentially leading to increased injury risks (13).

From a psychological viewpoint, the mental fatigue experienced by athletes can significantly influence their attention, decision-making capabilities, and overall performance. Schiphof-Godart, Roelands, and Hettinga (2018) explore how mental fatigue impairs endurance performance by altering the perceived effort and potentially decreasing motivation. In high-stakes environments such as professional volleyball matches, the ability to maintain mental clarity and focus is essential, underscoring the need for mental training and recovery strategies (10).

Neurophysiological correlates of fatigue also shed light on the broader impacts on an athlete's cognitive functions. Ortelli et al. (2021) examined the neurological manifestations of fatigue in patients post-COVID-19, finding significant impairments in neuropsychological functioning that mirror challenges faced by athletes experiencing fatigue. This research underscores the importance of comprehensive approaches to manage and mitigate fatigue impacts not only physically but also cognitively (7).

The direct impact of fatigue on performance can be seen in degraded reaction times and decreased accuracy, both of which are critical for volleyball. Studies like those by Zwierko et al. (2022) have identified specific perceptual-cognitive and motor determinants of agility in volleyball, illustrating how fatigue can diminish a player's reactive agility, a key component of successful defensive and offensive actions (8). Similarly, research on the relationship between cognitive functions and physical performance in youth volleyball players by Trecroci et al. (2021) emphasizes that cognitive decline due to fatigue adversely affects players' abilities to perform complex movements and make strategic decisions during games (6).

While significant strides have been made in understanding the multifaceted effects of fatigue on athletes, gaps remain, particularly in the integrative management of physiological and psychological fatigue in volleyball. This study aims to fill these gaps by examining the specific impacts of performance fatigue on visual perception, concentration, and reaction time among professional female volleyball players. By investigating these aspects, the research hopes to contribute valuable insights into effective strategies for monitoring, managing, and mitigating fatigue to enhance athlete performance and well-being.

2. Methods and Materials

2.1 Study Design and Participants

This study was designed as a quasi-experimental research project aimed at exploring the effects of performance fatigue on three critical performance parameters in professional female volleyball players: visual perception, concentration, and reaction time. The goal was to provide a detailed assessment of how induced fatigue impacts these cognitive and perceptual domains, which are crucial for high-level performance in volleyball.

The study population comprised all professional female volleyball players aged 18 to 25 from the city of Qazvin. The study recruited 24 professional female volleyball players from elite clubs, aged between 18 and 25 years. Participants were selected based on specific inclusion criteria: active competitive players with at least three years of professional playing experience, free from any neurological or orthopedic conditions that could affect performance, and not currently taking any medications impacting cognitive or physical functions. Informed consent was obtained from all participants after explaining the study's purpose, procedures, and potential risks.

Following the fatigue protocol, participants underwent a series of tests to measure their visual perception, concentration, and reaction time. These tests were administered using the Vienna Test System (VTS), which provides a reliable and validated platform for assessing cognitive functions in athletes. The VTS tests employed were specifically chosen for their relevance to the perceptual and cognitive demands of volleyball.

Data were collected in two sessions: baseline (pre-fatigue) and post-fatigue, with each session conducted on separate days to prevent carry-over effects. Each testing session began with a standardized warm-up followed by baseline measurements. The fatigue protocol was then administered, immediately followed by the post-fatigue assessments to ensure that the timing of measurements accurately reflected the state of fatigue.

2.2 Measures

Vienna Test System (VTS): The Vienna Test System is one of the pioneering computerized systems used in psychological assessments. It offers an unparalleled level of objectivity and precision, characteristics often unattainable with traditional pen-and-paper tests. The system provides rapid and accurate scoring and is designed to assess a broad spectrum of general abilities, specific skills, personality structure, interests, motivation, and clinical tests. The comprehensive range of tests available on this system is utilized both in clinical environments and research settings. The VTS is particularly noted for its application in sports psychology, where it helps evaluate athletes' cognitive and motor abilities, psychological readiness, and other attributes critical to performance in competitive environments.

LVT (Luminance-Vision Test): This test is used to assess visual perception. It involves tracking simple light patterns in a moderately complex environment without being distracted by other pathways, all under time pressure. The performance metrics for this test include the quality and speed of visual perception.

COG (Cognitive Operations Test): This test measures concentration. Unlike traditional concentration tests, which often feature static and repetitive tasks, the COG test includes varied complexity and requires quick decision-making to compare shapes and identify matches among multiple options. This dynamic setup helps gauge the subject's attention control, reaction speed, selective attention, and overall cognitive endurance throughout the task.

MDT (Motion Detection Test): This test evaluates reaction time, where the subject must respond as quickly as possible to specific visual cues. The MDT allows for the separation of "reaction time" from "movement time," providing a detailed measure of the subject's response capabilities in scenarios that require both quick decision-making and physical reaction.

Weight Measurement: Participants were weighed without shoes and in minimal clothing, standing on a scale with weight evenly distributed between both feet. The weight was measured in kilograms.

Height Measurement: Participants' height was measured using a wall-mounted stadiometer with a precision of 0.1 cm. Participants stood without shoes, back against the wall where the stadiometer was mounted, ensuring that their heels, buttocks, shoulders, and head were in line. Height was measured in centimeters while they faced forward.

These tools and tests are integrated into the research methodology to provide comprehensive data on the psychological and motor functions of the athletes, which are crucial for understanding the impact of performance fatigue on professional female volleyball players. The VTS system, with its high level of reliability and validity, supports rigorous assessment and ensures that the data collected are both accurate and applicable to real-world settings.

2.3 Intervention Protocol

The fatigue protocol used in this study was functional and specific to volleyball, consisting of several repetitive cycles until fatigue was achieved. Each cycle of the functional fatigue protocol included three stations (SEMO agility drill, 10 lunge movements, and 10 rapid height jumps) as specified by Shaw (2008). After completing these stations, participants immediately returned to the starting point to begin a new cycle, continuing until the completion time increased by 50% compared to the baseline. Verbal encouragement was provided to athletes throughout the protocol (11). Once participants felt fatigued, lactate levels were measured using a lactometer to ensure exhaustion before retesting with the Vienna tests in a quiet place for post-testing. The control group also performed the tests without inducing fatigue on the same day.

2.4 Data Analysis

The data were analyzed using repeated measures ANOVA to compare the pre- and post-fatigue measurements for each of the three performance parameters. This statistical approach was chosen to evaluate within-subjects effects and the interaction between time (pre vs. post) and fatigue on performance outcomes. Significance was set at $p < 0.05$, and all analyses were performed using SPSS software.

3. Findings and Results

Table 1 displays the means and standard deviations for visual perception, concentration, and reaction time for both the experimental group experiencing performance fatigue and the control group, measured before and after the test procedures.

Table 1. Mean and Standard Deviation of Study Variables in Experimental and Control Groups Before and After Tests

Variable	Group	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD
Visual Perception	Control	12.83	2.03	17.41	0.66
	Fatigue	13.83	2.72	13.91	2.35
Concentration (Correct)	Control	19.66	1.72	22.58	1.31
	Fatigue	20.00	2.21	21.00	2.52
Concentration (Withdrawal)	Control	31.00	1.70	34.16	1.74
	Fatigue	31.41	1.88	32.08	2.46
Reaction Time	Control	737.25	19.02	789.50	46.28
	Fatigue	789.50	21.77	730.08	14.42

Before conducting the primary statistical analyses, we rigorously checked and confirmed the necessary assumptions to ensure the validity of our results. Normality of data distribution was verified using Shapiro-Wilk tests, with all variables showing values suggesting normal distribution ($p > 0.05$). Homogeneity of variances was confirmed through Levene's Test, which indicated no significant deviations across the groups ($p > 0.05$). Additionally, the assumption of sphericity was assessed using Mauchly's Test of Sphericity; results were within acceptable limits ($p > 0.05$), indicating that the variances of the differences between all possible pairs of groups were equal. These checks ensured that the ANOVA conducted was robust and the findings from the study reliable. By confirming these assumptions, we safeguarded the integrity and accuracy of our statistical analyses and subsequent conclusions drawn from this research.

The results of the two-way ANOVA (Fatigue × Time) for visual perception showed (Table 2):

A significant main effect of time on the component of visual perception ($F(1, 22) = 10.575$, $p = 0.004$, $\eta^2 = 0.325$).

A significant main effect of the intervention on the component of visual perception ($F(1, 22) = 7.205$, $p = 0.014$, $\eta^2 = 0.247$).

A significant interaction effect of fatigue and time on visual perception ($F(1, 22) = 9.833$, $p = 0.005$, $\eta^2 = 0.309$). Thus, the null hypothesis is rejected, meaning performance fatigue significantly impacts the visual perception of professional female volleyball players, leading to a decrease in performance.

Table 2. Results of Two-Way ANOVA for Visual Perception

Source	SS	Df	MS	F	Sig.	η²
Time	65.333	1	65.333	10.575	0.004	0.325
Fatigue × Time	60.750	1	60.750	9.833	0.005	0.309
Error	135.917	22	6.178			
Fatigue	18.750	1	18.750	7.205	0.014	0.247
Error	57.250	22	2.602			

The results of the two-way ANOVA (Game × Time) in correct choices showed (Table 3):

A significant main effect of time on concentration in correct choices ($F(1, 22) = 18.256$, $p < 0.001$, $\eta^2 = 0.454$), indicating that irrespective of the groups, the mean concentration level differed significantly from pre-test to post-test.

A significant main effect of fatigue on concentration in correct choices ($F(1, 22) = 0.858$, $p = 0.364$, $\eta^2 = 0.038$).

A significant interaction effect of fatigue and time on concentration in correct choices ($F(1, 22) = 4.372$, $p = 0.048$, $\eta^2 = 0.166$). Therefore, the null hypothesis is rejected, indicating that performance fatigue significantly impacts the concentration of professional female volleyball players in making correct choices, leading to a reduction in performance.

Table 3. Results of Two-Way ANOVA for Concentration in Correct Choices

Source	SS	df	MS	F	Sig.	η²
Time	46.021	1	46.021	18.256	0.000	0.454
Fatigue × Time	11.021	1	11.021	4.372	0.048	0.166
Error	55.458	22	2.521			
Fatigue	4.688	1	4.688	0.858	0.364	0.038
Error	120.125	22	5.460			

The results of the two-way ANOVA (Game × Time) in withdrawals showed (Table 4):

A significant main effect of time on concentration in withdrawals ($F(1, 22) = 24.145$, $p < 0.001$, $\eta^2 = 0.523$), indicating that, regardless of the groups, the mean concentration level changed significantly from pre-test to post-test.

A significant main effect of fatigue on concentration in withdrawals ($F(1, 22) = 1.396$, $p = 0.250$, $\eta^2 = 0.060$).

A significant interaction effect of fatigue and time on concentration in withdrawals ($F(1, 22) = 10.270$, $p = 0.004$, $\eta^2 = 0.318$). Therefore, the null hypothesis is rejected, meaning that performance fatigue significantly affects the concentration in correct withdrawals in professional female volleyball players, leading to a decrease in this ability.

Table 4. Results of Two-Way ANOVA for Concentration in Withdrawals

Source	SS	Df	MS	F	Sig.	η²
Time	44.083	1	44.083	24.145	0.000	0.523
Fatigue × Time	18.750	1	18.750	10.270	0.004	0.318
Error	40.167	22	1.826			
Fatigue	8.333	1	8.333	1.396	0.250	0.060
Error	131.333	22	5.970			

The results of the two-way ANOVA (Fatigue × Time) for reaction time showed (Table 5):

A significant main effect of time on reaction time ($F(1, 22) = 12.861$, $p = 0.002$, $\eta^2 = 0.369$), indicating that, regardless of the groups, the average reaction time differed from pre-test to post-test.

A significant main effect of fatigue on reaction time ($F(1, 22) = 7.917$, $p = 0.010$, $\eta^2 = 0.265$).

A significant interaction effect of fatigue and time on the reaction time of professional female volleyball players ($F(1, 22) = 29.246$, $p < 0.001$, $\eta^2 = 0.571$). Hence, the null hypothesis is rejected, suggesting that performance fatigue significantly affects the reaction time of professional female volleyball players, leading to an increase in reaction time.

Table 5. Results of Two-Way ANOVA for Reaction Time

Source	SS	df	MS	F	Sig.	η²
Time	5208.333	1	5208.333	12.861	0.002	0.369
Fatigue × Time	11844.083	1	11844.083	29.246	0.000	0.571
Error	8909.583	22	404.981			
Fatigue	9408.000	1	9408.000	7.917	0.010	0.265
Error	26143.250	22	1188.330			

4. Discussion

The primary aim of this study was to investigate the effects of performance fatigue on visual perception, concentration, and reaction time in professional female volleyball players. Understanding these impacts is crucial for developing effective strategies to enhance athlete performance and inform coaching practices and training protocols specifically tailored to manage fatigue.

The results of this study indicate that performance fatigue significantly affects all three measured parameters—visual perception, concentration, and reaction time. Notably, visual perception and concentration were adversely affected, with both showing measurable declines in post-test assessments compared to pre-test conditions. Conversely, reaction times were significantly longer under conditions of fatigue, indicating slower physical and cognitive responses during gameplay.

The findings of decreased visual perception under fatigue align with the research by Honda et al. (2018), who demonstrated that fatigue could impair visual tracking and processing speed, critical factors in sports requiring quick visual assessment and decision-making like volleyball (3). The degradation in visual perception could be attributed to the reduced neural efficiency as cognitive resources are strained under fatigue (1).

Similarly, the observed decline in concentration corroborates with findings from Trecroci et al. (2021), who noted that cognitive functions crucial for maintaining focus and making split-second decisions are significantly compromised under physical exhaustion (6). The decline in concentration could be influenced by an increased perception of effort and decreased cognitive endurance, as suggested by Schiphof-Godart, Roelands, and Hettinga (2018), who discussed how mental fatigue could elevate the perceived difficulty of tasks, thus impairing sustained attention (10).

The increase in reaction time is consistent with the work of Zwierko et al. (2022), which identified fatigue as a critical factor slowing down an athlete's ability to react to rapid game developments (8). This delay in reaction times can be explained by the fatigue-induced impairments in neuromuscular coordination and a general slowdown in neural processing, as discussed by Enoka and Duchateau (2016). This slowdown reflects a compromised ability to process external stimuli swiftly and execute physical responses effectively (1).

Theoretically, the results can be framed within the context of the Central Governor Model, which posits that physical performance is regulated by the central nervous system primarily to preserve homeostasis and prevent overexertion (9, 14). In line with this theory, it could be posited that the observed decreases in cognitive performance parameters are protective mechanisms that reduce the risk of injury by limiting performance when the athlete is fatigued. Furthermore, the Attentional Control Theory provides insight into the cognitive findings of the study. This theory suggests that fatigue leads to a preference for processing salient stimuli at the cost of task-relevant cues, which could explain the decreased concentration levels observed in fatigued athletes (10, 12, 15).

5. Conclusion

This study explored the impact of performance fatigue on visual perception, concentration, and reaction time among professional female volleyball players. The findings underscore the significant adverse effects of fatigue, manifesting in diminished visual and cognitive capabilities and delayed reaction times. These results emphasize the importance of managing fatigue through appropriate training and recovery interventions to sustain high performance levels and safety in volleyball athletes. By demonstrating the extent to which fatigue can impair essential performance aspects, this research contributes critical insights that can help coaches and sports scientists develop more effective athlete monitoring and management strategies. The findings suggest that monitoring fatigue and implementing strategic recovery processes can play crucial roles in maintaining optimal performance levels in professional athletes.

One limitation of this study is its relatively small sample size, which might limit the generalizability of the findings to all professional female volleyball players. Additionally, the study's design, focusing exclusively on female athletes, may not reflect similar impacts in male athletes, who could exhibit different physiological and psychological responses to fatigue. Another limitation is the reliance on self-reported measures of fatigue which might not accurately capture the multifaceted nature of fatigue as physiological indicators were not comprehensively assessed.

Future research should consider employing a larger and more diverse sample to enhance the generalizability of the findings across different populations, including male athletes and those at varying levels of play. Studies could also integrate more objective physiological measures of fatigue, such as biomarkers or neuroimaging techniques, to provide a more comprehensive understanding of how fatigue affects the body and mind. Additionally, longitudinal studies could assess how the impacts of fatigue on performance might change over a competitive season or an athlete's career, providing insights into long-term strategies for managing athlete health and performance.

The implications of this study are significant for the development of tailored training and recovery programs. Coaches and sports performance staff should consider incorporating regular assessments of visual and cognitive functions into their routine evaluations of athlete readiness and fatigue levels. Implementing targeted interventions, such as cognitive training sessions, adequate sleep management strategies, and optimized nutrition plans, can help mitigate the negative effects of fatigue. Moreover, integrating these findings into daily practice could aid in the scheduling of training sessions to align with athletes' optimal performance times, thereby maximizing the effectiveness of training while reducing the risk of fatigue-related declines in performance.

Authors' Contributions

F.V. conceived of the presented idea, developed the theory, and performed the computations. Z.B. verified the analytical methods and supervised the findings of this work. M.T. encouraged F.V. and Z.B. to investigate the impact of performance fatigue and supervised the project. All authors discussed the results and contributed to the final manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We would like to express our gratitude to all individuals who helped us with the project.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

References

1. Enoka RR, Duchateau J. Translating Fatigue to Human Performance. Medicine & Science in Sports & Exercise. 2016. [PMID: 27015386] [PMCID: PMC5035715] [DOI]
2. Faghfouriazar M. The Effectiveness of Selected Perceptual-Motor Exercises on Working Memory and Quality of Life of Elderly Women. Aging Psychology. 2023;9(3):310-293.
3. Honda J, Chang SH, Kim K-J. The Effects of Vision Training, Neck Musculature Strength, and Reaction Time on Concussions in an Athletic Population. Journal of Exercise Rehabilitation. 2018. [PMID: 30443514] [PMCID: PMC6222152] [DOI]
4. Barkley RA. Sluggish cognitive tempo (concentration deficit disorder?): Current status, future directions, and a plea to change the name. Journal of abnormal child psychology. 2014;42:117-25. [PMID: 24234590] [DOI]
5. Taheri M, Valayi F. Aerobic Exercise Improves Attention and Quality of Sleep Among Professional Volleyball Players. Sleep and Hypnosis. 2018. [DOI]
6. Trecroci A, Duca M, Cavaggioni L, Rossi A, Scurati R, Longo S, et al. Relationship Between Cognitive Functions and Sport-Specific Physical Performance in Youth Volleyball Players. Brain Sciences. 2021. [PMID: 33673260] [PMCID: PMC7917811] [DOI]

7. Ortelli P, Ferrazzoli D, Sebastianelli L, Engl M, Romanello R, Nardone R, et al. Neuropsychological and Neurophysiological Correlates of Fatigue in Post-Acute Patients With Neurological Manifestations of COVID-19: Insights Into a Challenging Symptom. Journal of the Neurological Sciences. 2021. [PMID: 33359928] [PMCID: PMC7834526] [DOI]
8. Zwierko M, Jedziniak W, Popowczak M, Rokita A. Reactive Agility in Competitive Young Volleyball Players: A Gender Comparison of Perceptual-Cognitive and Motor Determinants. Journal of Human Kinetics. 2022. [PMID: 36643830] [PMCID: PMC9808806] [DOI]
9. Halson SL. Monitoring Training Load to Understand Fatigue in Athletes. Sports Medicine. 2014. [PMID: 25200666] [PMCID: PMC4213373] [DOI]
10. Schiphof-Godart L, Roelands B, Hettinga FJ. Drive in Sports: How Mental Fatigue Affects Endurance Performance. Frontiers in Psychology. 2018. [PMID: 30174627] [PMCID: PMC6107844] [DOI]
11. Guan Y, Bredin SSD, Jiang Q, Taunton J, Li Y, Wu N, Wu L. The Effect of Fatigue on Asymmetry Between Lower Limbs in Functional Performances in Elite Child Taekwondo Athletes. Journal of Orthopaedic Surgery and Research. 2021. [DOI]
12. Sun H, Soh KG, Roslan S, Mohd Rozilee Wazir Norjali W. Does Mental Fatigue Affect Skilled Performance in Athletes? A Systematic Review. Plos One. 2021. [PMID: 34648555] [PMCID: PMC8516214] [DOI]
13. Hadžić V, Sattler T, Veselko M, Marković G, Dervišević E. Strength Asymmetry of the Shoulders in Elite Volleyball Players. Journal of Athletic Training. 2014. [PMID: 24673238] [PMCID: PMC4080589] [DOI]
14. Kölling S, Duffield R, Erlacher D, Venter R, Halson SL. Sleep-Related Issues for Recovery and Performance in Athletes. International Journal of Sports Physiology and Performance. 2019. [PMID: 29651858] [DOI]
15. Rattray B, Argus CK, Martin K, Northey JM, Driller MW. Is It Time to Turn Our Attention Toward Central Mechanisms for Post-Exertional Recovery Strategies and Performance? Frontiers in Physiology. 2015. [PMID: 25852568] [PMCID: PMC4362407] [DOI]