Game Nexus

Effects of Time Pressure on Visual Processing and Shooting Accuracy in Skilled Futsal Players

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ABSTRACT

Time pressure limits perceptual processing and reduces decision-making accuracy, making it a key factor in perceptual–motor performance in sports. This study aimed to investigate how time pressure affects visual behavior and shooting accuracy in skilled futsal players. The population under consideration in this study consisted of male club-level futsal players who were right-footed and played in a pivot role. The study targeted a total of 24 talented players, aged 20-30 years old, using a purposive sampling technique. The players were allowed a total of 10 shots at a target set before them in different pressure situations. The time pressure situations were set to low (40 seconds), moderate (30 seconds), and high pressure (20 seconds). The players' visual behavior in firing shots at a goal under these pressure situations was recorded using an eye-tracking device. The accuracy of shots fired by players under these situations was measured using a standard Loughborough Soccer Shooting Test. Research analysis employed one-way analysis of variance to compare the different conditions of time pressure, with Bonferroni post hoc tests used to follow up on the ANOVA in pairwise comparisons, setting the significance level at 0.05 using SPSS software. Analysis of Variance: Results related to fixation duration were found to be significantly affected by time pressure ($p < 0.001$), while the accuracy of shooting was also significantly affected ($p < 0.001$). On the other hand, non-significant effects were witnessed for fixation number ($p = 0.670$) and eye saccade movement ($p = 0.976$). Pair comparison showed thatwith more time pressure, fixation duration reduces while the accuracy of shooting gets affected drastically. The study observations have proved that time pressure can be a major negative factor in perceptual-motor performance among skilled futsal players when it affects both visual fixation time and accuracy in shots.

Keywords: Futsal, Time Pressure, Visual Behavior, Shooting Accuracy

Introduction

Futsal is a popular and fast-paced team sport characterized by a smaller playing area, fewer players, and high-tempo gameplay. These unique constraints require players to continuously perform rapid visual searches and execute skills under very short time limits (1, 2). In such situations, athletes frequently experience time pressure, defined as a condition requiring rapid motor responses, visual searches, and cognitive decisions under tight temporal constraints, often accompanied by psychological distress (3). These demands make futsal particularly challenging, as players must operate with reduced time and space for both information gathering and skill execution (4). When decisions and actions must be executed rapidly, the speed-accuracy trade-off, formalized by Fitts' law, becomes particularly relevant. Fitts' law predicts that as the time available for decision-making and movement execution decreases, accuracy is likely to diminish (5). This relationship is especially evident in futsal shooting situations, where players under defensive pressure must make split-second decisions and execute shots with limited time (6, 7). Consequently, players who are forced to shoot quickly often experience decreased shooting accuracy (8).

According to dynamical systems theory and the ecological approach to perception and action, time pressure functions as a task constraint to which the athlete's perceptual-motor system must adapt (9). Within this framework, performance emerges from the continuous interaction between task constraints (e.g., time pressure, defensive pressure), environmental constraints (e.g., playing area, opponent positioning), and individual constraints (e.g., skill level, experience), Understanding how athletes adapt their perceptual-motor behaviors under time pressure can provide valuable insights into the mechanisms underlying successful performance in demanding situations (10).

The coordination of the perceptual-visual system under the effect of time pressure is beneficial in terms of helping athletes retain their performance levels even when they are under difficult situations (11). Visual behavior parameters include several components, including fixation duration and fixation counts, Fixation duration is the time taken to focus the eyes on a single point in an effort to process visual information, while fixations entail fast eye movements called saccadic movements (12). The process entails the rapid shifting of the eyes between several points in the visual scene as the observer tries to view the environmental information. Commonly, these parameters are evaluated using an eye-tracking system, where the sequential position of the pupil in each frame, as well as the procedure duration, is recorded (13).

In sports requiring rapid and accurate responses, visual search patterns are essential not only for technical execution but also for tactical decision-making, Players must quickly analyze the field, including teammate positions and opponent movements, all within fractions of a second (14)Previous research has demonstrated that time pressure significantly influences these visual patterns, leading to shorter fixation durations and altered environmental scanning strategies (15).

The previous studies have primarily examined either aspect of performance under pressure separately. For instance, there have been studies on alterations in shooting accuracy (16-18). Additionally, the previous studies have concentrated on the visual aspect, such as the length of fixations (19, 20). Nevertheless, few studies have examined both factors (11, 17, 21).

While time pressure is recognized as a critical constraint affecting perceptual-motor performance in sport, and efficient visual information extraction is essential for successful performance (22), most investigations have been conducted in controlled laboratory settings involving sports such as basketball and handball. Consequently, there is limited understanding of how time pressure affects visual search processes and their relationship to performance outcomes in ecologically valid conditions. Furthermore, no study to date has systematically examined both visual behavior (fixation duration, fixation count, saccadic movements) and shooting accuracy in futsal players under varying levels of time pressure in a controlled yet ecologically meaningful setting. Therefore, the aim of this study was to investigate the effects of different levels of time pressure (low, moderate, and high) on visual processing components and shooting accuracy among skilled futsal players. Specifically, we examined how fixation duration, fixation count, saccadic movements, and shooting performance change as time pressure increases, and how these visual adaptations relate to the speed-accuracy trade-off in futsal shooting. Based on previous research, we hypothesized that time pressure would significantly affect both visual behavior and shooting accuracy, with players adopting adaptive visual strategies to maintain performance under temporal constraints.

Methods and Materials

This study utilized a quasi-experimental design with a within-subjects, repeated-measures approach. The research population consisted of active club-level futsal players. To recruit skilled players, several teams from the First and Premier Leagues were contacted, and necessary arrangements were made to collaborate with them. A total of 24 male players, with a mean age of 24.7 ± 1.8 years and an average of five years of experience in first-level futsal, were selected using purposive sampling. Inclusion criteria required participants to have normal visual health and no serious lower-limb injuries within the past six months (23).

Purposive sampling was used in this study because it aimed to examine the performance of skilled players under time pressure. Ensuring a homogenous skill level and experience among the participants enhances the validity of the results when analyzing visual patterns and shooting accuracy. This consistency helps ensure that the findings genuinely reflect the performance of skilled players. Based on prior research in futsal, the chosen sample size is deemed adequate for exploring the effects of time pressure (24).

Instruments and Equipment

Eye-Tracker:

To capture players’ visual behavior during task execution, an eye-tracking system (Pupil Core, Pupil Labs, Germany) was employed. This system enables precise and reliable measurement of key visual parameters, including fixation duration, number of fixations, and saccadic eye movements. Before each experimental trial, a standard calibration procedure was conducted to ensure the accuracy and validity of gaze data acquisition.

Visual variables were operationalized as follows: the total number of fixations and the number of saccadic movements defined as gaze transitions between consecutive fixations were calculated across ten shooting attempts for each participant. Fixation duration was computed as the mean duration per fixation across all recorded shots.

Modified Loughborough Soccer Shooting Test: In this study, we adapted the modified Loughborough Soccer Shooting Test to fit futsal goal dimensions. Scoring and recording were organized by dividing the goal into nine sections, each based on difficulty, height, and angle, with specific scores assigned to each section. This scoring system was derived from the original soccer goal scoring criteria, proportionally adjusted for the dimensions of a futsal goal (see Figure 1). Each attempt was recorded by the tester, noting how the ball made contact with the different sections of the goal. The final score for each player was calculated by summing the points earned from all shots directed at the goal. (25)

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Figure 1: Loughborough Shooting Test Scoring System

Futsal Ball: A standard adult futsal ball made of leather, weighing between 390 and 430 grams, with a circumference of 62–64 cm.

Waterloo Footedness Questionnaire

The revised Waterloo Footedness Questionnaire comprises twelve questions to identify a person's dominant foot. Six questions focus on the functioning capacity of the person, and the remaining six questions probe into the functioning of the foot while performing actions in terms of support and balance tasks. Each question requires a response on the lines of foot dominance identified as follows: 'Always left' scored as −2, 'Usually left' as −1, 'Both feet' as 0, 'Usually right' as 1, and 'Always right' scored as 2.

All the items are completed, and the score for the right and left foot is then added up to obtain the total score, which shows the preference/dominance for the right and left foot. A positive score shows preference for the right foot, and a negative score shows preference for the left foot. The scale enjoys a Cronbach's Alpha level of 0.92.

Quantitative Phase

To control for order effects related to the time-pressure conditions, a counterbalanced design was implemented to determine the sequence of conditions for each participant. Six different sequences of condition presentation were created: Low → Moderate → High, Low → High → Moderate, Moderate → Low → High, Moderate → High → Low, High → Low → Moderate, and High → Moderate → Low. Each participant was randomly assigned to one of these sequences, with four participants allocated to each sequence to ensure a balanced distribution of conditions across the group. At the beginning of the study, an initial briefing session was conducted for the participants to explain the research objectives. The players then engaged in a 5-minute general warm-up, which included light jogging and dynamic stretching, followed by a 5-minute sport-specific warm-up that consisted of shooting and short passing drills. After the warm-up, the eye-tracking glasses were fitted, and calibration was performed by aligning the gaze and pupil on ten designated points using a laptop. Once calibration was complete, ten balls were placed six meters from the goal line and spaced appropriately apart. In the low time-pressure condition, participants were required to complete 10 shots within 40 seconds, averaging 4 seconds per shot. In the moderate time-pressure condition, this time was reduced to 30 seconds, averaging 3 seconds per shot. In the high time-pressure condition, participants had only 20 seconds to complete all 10 shots. To ensure that time pressure was experienced consistently across all shots in each condition, the duration for each shot was measured separately. The time-pressure protocol for shooting was implemented in accordance with the study by Umberto et al. (24). In that study, futsal players took shots during 18 real matches, with inter-shot intervals varying from 0.36 seconds (high time pressure) to 5.28 seconds (low time pressure). In the present study, we aimed to examine the effects of time pressure more precisely by using shot times of 2, 3, and 4 seconds, which fall within the interval reported by Umberto et al. This approach allowed us to replicate the previous study while also closely investigating intermediate intervals, specifically the moderate time-pressure condition of 3 seconds. Shooting accuracy was assessed using the modified Loughborough Soccer Shooting Test. Additionally, fixation counts and durations were recorded using eye-tracking glasses, and saccadic movements were calculated based on consecutive fixations.

Data Analysis

Descriptive statistics, including the mean and standard deviation, were calculated for the data. To evaluate the study hypotheses, we performed an analysis of variance (ANOVA). In cases where significant main effects were identified, Bonferroni post hoc tests were conducted. The significance level for all tests was set at 0.05. All analyses were conducted using SPSS version 27.

Findings and Results

Descriptive indices, including the mean and standard deviation of the study variables (fixation duration, number of fixations, saccadic movements, and shooting accuracy) across the three time-pressure levels (low, moderate, and high), are presented in Table 1.

Table 1. Mean and standard deviation of the study variables under different time-pressure conditions

Variable	Low Time Pressure (40 s)	Moderate Time Pressure (30 s)	High Time Pressure (20 s)
Number of fixations	24.79 ± 2.57	24.96 ± 2.52	25.46 ± 2.91
Fixation duration (ms)	217.40 ± 17.97	193.41 ± 15.16	147.83 ± 16.55
Saccadic movements	24.33 ± 2.68	24.50 ± 2.55	24.46 ± 2.91
Shooting accuracy (score)	42.21 ± 2.37	37.54 ± 4.19	30.54 ± 2.34

As shown in Table 1, with increasing time pressure, the mean fixation duration and shooting accuracy decreased, whereas no notable changes were observed in the number of fixations or saccadic movements. To assess data normality, the Shapiro–

Wilk test was used. The results indicated that most variables followed a normal distribution ($p > 0.05$). Homogeneity of variance was also examined using Levene's test, which showed that the assumption of equal variances was met for most variables.

Table 2. Statistical indices of the ANOVA test, including F-value, degrees of freedom, significance level, and effect size

Variable	F	df	p-value	η^2
Number of fixations	0.403	2, 69	0.670	0.011
Fixation duration	108.75	2, 69	0.001	0.759
Saccadic movements	0.024	2, 69	0.976	0.000
Shooting accuracy	86.53	2, 69	0.001	0.715

The ANOVA results (Table 2) indicated that time pressure had a significant effect on visual fixation duration and shooting accuracy, whereas no significant effects were observed for the number of fixations or saccadic movements. Overall, as time pressure increased, fixation duration decreased, and shooting accuracy showed a significant decline. In contrast, the number of visual fixations and saccadic movements did not differ significantly across the three time-pressure levels.

To examine differences between time-pressure levels more precisely, pairwise comparisons with Bonferroni correction were conducted. As shown in Figure 1, fixation duration was significantly longer under low time pressure compared to moderate ($p < 0.001$) and high pressure ($p < 0.001$). Additionally, the difference between moderate and high pressure was also significant ($p < 0.001$), indicating a gradual and significant decrease in fixation duration from low to high time pressure. These findings suggest that as time pressure increases, players allocate less time to focus on the target, and this reduction occurs consistently across all pressure levels. A similar pattern was observed for shooting accuracy. Accuracy under low time pressure was significantly higher than under moderate ($p < 0.001$) and high pressure ($p < 0.001$), and a significant difference was also found between moderate and high pressure ($p < 0.001$). Thus, increasing time pressure led to a continuous and significant decline in shooting accuracy, with reductions evident not only between low and high levels but also between moderate and high levels.

In contrast, Bonferroni post hoc tests for the number of fixations and saccadic movements revealed no significant differences between the time-pressure conditions ($p > 0.05$). These results indicate that players maintained their overall visual exploration patterns across all pressure levels, with no notable changes in the number of fixations or rapid eye movements.

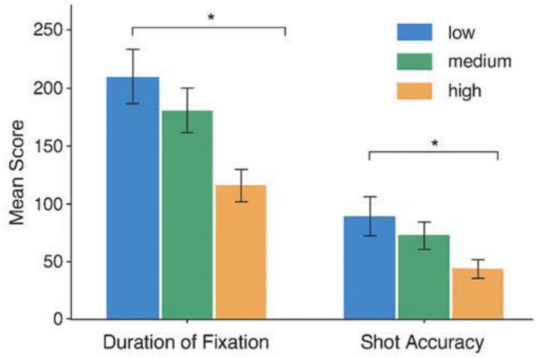

Figure 2. Results of the Bonferroni post hoc test

Disuccion and Conclusion

This study investigated the effects of different levels of time pressure (low, moderate, and high) on visual components and shooting accuracy among skilled futsal players. The results revealed that increasing time pressure caused significant changes in certain variables. Specifically, both visual fixation duration and shooting accuracy decreased notably as the available time diminished. In contrast, the number of fixations and saccadic movements showed less sensitivity to variations in time pressure, remaining relatively stable across all conditions.

Increasing time pressure did not significantly affect the number of visual fixations or saccadic movements in skilled futsal players. It appears that when faced with time pressure, these players unconsciously adopt specific visual strategies to optimize their performance. One such strategy involves maintaining a consistent level of fixations and saccadic movements, This suggests that, despite the pressure of time, players strive to keep their information processing at a steady pace (26). According to Long-Term Working Memory Theory (27), skilled performers store domain-specific patterns in long-term memory that can be rapidly accessed through retrieval structures in working memory. This theoretical framework explains why skilled futsal players maintained their number of fixations under time pressure: the relevant perceptual patterns (teammate positions, opponent movements, goal location) are already encoded in long-term memory, requiring only quick verification rather than extended visual exploration. The stability of fixation counts reflects efficient retrieval of well-learned visual patterns without conscious.

A comparison with previous studies shows that the current findings contradict some earlier research. For example, one study investigating the effects of time pressure on visual behavior in basketball found that skilled athletes tend to reduce the number of their fixations when facing time pressure (11). The differences in saccadic movements and fixations between futsal and basketball under time pressure can be attributed to the unique demands of each sport. In futsal, players often focus on specific targets, which may decrease the need to adjust the number of saccades or fixations, even when time is limited. Similarly, a study on basketball found that skilled players tended to use fewer eye fixations, This variation may also arise from the nature of the sport and the specific research protocol, depending on whether the individual is completing a task directly or simply predicting another player's actions (28). This cross-sport discrepancy highlights the domain-specificity of perceptual-cognitive expertise, where visual strategies are finely tuned to the unique constraints of each sport's environmental demands rather than reflecting a generalizable skill across all athletic.

In a study conducted by Jesus et al. (2023), time pressure was used as an intervention to examine changes in saccadic movements among soccer players. The results indicated that players trained under time-pressure conditions exhibited a higher number of saccades compared to those in no-pressure conditions. This finding is somewhat consistent with the present study, which also found that saccade counts did not decrease under time pressure. Skilled futsal players, due to their extensive experience and frequent exposure to high-pressure situations, can adapt their performance to meet the demands of time-constrained conditions (26). Skilled athletes have a natural ability to focus on key cues and relevant information, especially when under time pressure, This skill enables them to make accurate decisions while maintaining a similar or even greater number of eye movements (fixations and saccades) compared to normal conditions (29). Through experience and extensive practice, these athletes develop more effective visual search strategies, which allow for faster information processing. As a result, they do not feel the need to reduce the number of eye movements to speed up their decision-making, Instead, by utilizing more precise and selective search patterns, they can efficiently gather and use all available information to achieve optimal outcomes within a limited timeframe (30).

The practical interpretation of these findings indicates that skilled players, when faced with high time pressure, tend to reduce the depth of their gaze instead of changing the number of fixations to manage their limited cognitive resources. This strategy has its advantages, such as maintaining reaction speed and concentrating on essential cues. However, it also comes with drawbacks; shorter fixation durations may result in missing vital environmental information and increase the chances of minor targeting errors with the ball (31). The mean fixation durations under low, moderate, and high time-pressure conditions were 217.40 ms, 193.41 ms, and 147.83 ms, respectively, showing a significant decrease as time pressure increased. As time pressure increases, skilled players naturally adopt strategies to reduce information-processing time in order to enhance their reaction speed. One such strategy is shortening the duration of each fixation. This means that instead of spending more time processing fine details at each point, players scan environmental information more quickly and make faster decisions. Reducing fixation duration allows players to continue processing visual information, but within a shorter time frame (32). This illustrates a method of optimizing cognitive resources. According to Cognitive Load Theory (Sweller, 1988), working memory has limited capacity. Time pressure increases intrinsic cognitive load by demanding faster processing of task-relevant information. When intrinsic load exceeds available capacity, performance degrades. The stable number of fixations but reduced duration suggests players maintained the same breadth of visual search (managing extraneous load) while sacrificing processing depth at each fixation (intrinsic load exceeded capacity) (33). This represents an adaptive allocation of limited cognitive resources under temporal constraints.

When under time pressure, the brain tries to enhance information-processing speed and concentrate on important environmental cues, while minimizing the time spent on each detail (34), As a result, players can perform effectively and maintain their reaction speed, even if the depth of information processing is temporarily decreased. Previous studies have reported similar findings; for instance, research in basketball has shown that time and performance pressure result in shorter fixation durations (11).

When under time pressure, individuals often use visual search strategies that involve shorter fixation durations (11), This means that they make more saccades, or rapid eye movements, to quickly scan different areas of a scene.

However, the study by Bohloul et al. found that under outcome- and monitoring-related pressure, fixation duration significantly increased compared to no-pressure conditions, which contrasts with the present findings (35). These changes may indicate that players are making a greater effort to process information thoroughly, especially in high-pressure situations with limited time. An increase in the duration of fixations in these contexts can signal enhanced focus and attention to crucial decision-making details, which helps improve accuracy when under psychological stress (11, 36). Attentional Control Theory helps explain this discrepancy by distinguishing between different types of pressure. The theory differentiates between processing efficiency (how quickly tasks are performed) and processing effectiveness (how accurately they are performed). Time pressure in the present study prioritized efficiency (shorter fixations, faster decisions), while outcome-related pressure in Bohloul et al. prioritized effectiveness (longer fixations, maintained accuracy). This theoretical distinction clarifies why different pressure manipulations can produce opposite effects on fixation duration (37).

Some studies have reported conflicting results. This discrepancy may be due to differences in the research tasks, the level of time pressure, and the experimental conditions. In that study, participants had more time to process crucial information, and the time pressure was not as intense as in the current study (38). However, Chong et al. reported in their study that high-skilled athletes exhibit shorter fixation durations. This strategy allows them to extract essential information more quickly and accurately (39).

The findings of this study indicate that time pressure significantly negatively affects the shooting accuracy of futsal players. Under low, moderate, and high time-pressure conditions, the mean shooting accuracy dropped to 42.21, 36.57, and 30.54, respectively. Statistical analysis demonstrated that increased time pressure diminishes players' ability to accurately target and control their shots. This decline in accuracy may be attributed to shorter fixation durations and reduced depth of visual processing, or to the players opting for easier target areas based on the Loughborough goal-scoring divisions. Furthermore, time pressure limits players' cognitive resources, resulting in even skilled athletes, who maintain their number of fixations and saccades, being unable to fully preserve the quality of their targeting and shooting performance (40).

The findings support the speed–accuracy trade-off theory, which is based on Fitts' law. Fitts' law mathematically formalizes this relationship as $MT = a + b \log_2(2D/W)$, where MT is movement time, D is distance to target, and W is target width. The logarithmic component, known as the index of difficulty (ID), represents the precision demands of the task. When time pressure reduces available movement time, the equation predicts that either accuracy must decrease (effective target width increases) or movements must be directed toward larger targets (41). In this study, players maintained successful shots but shifted toward easier target areas, consistent with the law's predictions. Players implicitly adjusted their aiming strategy to match the biomechanical constraints described by Fitts' law, selecting targets that minimized the index of difficulty under severe time constraints. This principle states that as the speed of a movement increases, its accuracy tends to decrease. In sports like futsal, where players must make decisions within just a few hundred milliseconds, this trade-off is especially noticeable. As time pressure builds, players have less time to assess their surroundings, choose the best angle, and fine-tune their shooting movements (42). As a result, they often resort to a quick-response strategy that sacrifices accuracy, or hesitate and miss the best opportunity. The strategy a player adopts largely depends on their skill level, experience, and motor memory (43). This is consistent with Schema Theory, which proposes that motor programs become more adaptable with varied practice, allowing skilled players to adjust their aiming strategies based on available time (44).

Previous studies in various sports have also reported a decrease in throwing accuracy under time pressure. The present findings support this perspective (45). Although a decrease in accuracy was observed, players' performance remained at an acceptable level. This aligns with the study by McLarin and colleagues, which examined the speed–accuracy trade-off in badminton (46).

In other words, players executed shots without errors and successfully scored goals, but tended to select target areas that were easier to reach, minimizing the likelihood of mistakes. This adaptive behavior reflects Expected Value Theory in decision-making: under time pressure, players unconsciously calculate the probability of success for each target option and select the option with the highest expected value. By choosing easier targets, they trade optimal outcomes for assured success a rational adaptation to temporal constraints that balances risk and reward under limited processing time (47).

Time pressure can significantly reduce cognitive capacity and hinder the ability to perform cognitive and motor tasks simultaneously, as both thinking and execution require adequate time (48). Multiple Resource Theory suggests that when tasks compete for the same cognitive resources (e.g., visual processing and motor planning both requiring attention), performance degrades under time pressure (49). In futsal, players must simultaneously process visual information and execute motor responses tasks that draw from overlapping attentional pools, making dual-task performance particularly vulnerable to temporal constraints (50). However, under time pressure, choosing these strategies can be a practical and adaptive response, as prioritizing speed and quick reactions becomes essential. Targeted training and practice can enhance players' performance even when they are under time pressure. This aligns with the Principle of Specificity in motor learning, which states that training adaptations are most pronounced when practice conditions closely mimic performance demands (51). Nevertheless, time pressure generally limits performance quality; longer time frames are usually associated with higher accuracy and better execution (52).

This study demonstrated that time pressure significantly affects visual processing and shooting accuracy in skilled futsal players. As time pressure increased, fixation duration decreased while the number of fixations and saccadic movements remained stable. This indicates that skilled players maintain visual search breadth but reduce processing depth at each fixation to cope with temporal constraints. However, shooting accuracy declined progressively under pressure, reflecting the speed-accuracy trade-off described by Fitts' law. Players maintained functional performance by selecting easier target areas, suggesting an implicit risk-management strategy. These findings highlight the importance of incorporating time-pressure training to help players develop adaptive visual strategies for game-like conditions.

Several limitations should be considered. First, the sample consisted only of skilled male futsal players, which limits generalizability to other populations. Also, only the immediate effects of time pressure were examined. Fourth, the neural mechanisms underlying visual adaptations were not examined. Future research should: (1) use mobile eye-tracking during actual futsal play, (2) include players of different skill levels and genders, (3) conduct longitudinal studies to track visual strategy development, (4) examine neural correlates using EEG or fMRI).

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AI Use Statement

In this study, AI tools were used solely to assist with writing and language editing.

Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles involving human participants were strictly followed throughout the design, execution, and reporting of this study. Approval was obtained from the Institutional Review Board (IRB) of the University of Tehran (Approval No.: IR.UT.SPORT.REC.1403.124), and informed consent was obtained from all participants prior to their participation.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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