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Decision making and visual perception in soccer players under pressure

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Abstract

Background: Players are under more pressure in soccer matches. In those conditions, they must use visual information to make better decisions. However, few studies have investigated such conditions of soccer players.

Aim: The aim of the present study investigates the effect of under-pressure conditions on decision-making and visual search behavior of soccer players.

Materials and Methods: Eighteen soccer players with a mean age of 14.5 (and SD ±1.5) from Tehran Youth Premier League took part in this study. Decision-making task included 60 images of 3 simulated soccer conditions on a monitor including neutral (no pressure), result pressure, and monitoring pressure. During all of these conditions, eye movements were assessed by an eye tracker device.

Results: The results of repeated measures ANOVA test showed the speed and accuracy of decision making, the number of fixations and the mean duration of eye fixation were significantly affected in all three conditions. In addition, the results showed a significant reduction in decision-making speed in two conditions of result and monitoring pressures and a significant increase in decision accuracy and the mean number and duration of eye fixation in the two conditions of result and monitoring pressures compared to neutral pressure.

Conclusion: Due to the changes in visual and speed-accuracy mechanism of decision making and the importance of these factors in the successful performance of soccer players, it is recommended that soccer coaches create psychological pressure conditions during training sessions, ask players to see with better concentration and attention, and to decide more quickly and accurately so that they can better overcome the challenges in competition environment.

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1. Introduction

Competitive sporting environments include some skills. The conditions of a competitive environment, the variables affecting the optimal performance of a skill, and the outcome of a competition are always of interest to athletes, coaches, trainers, and researchers. It has repeatedly been witnessed that an athlete performs as a novice during some sensitive moments of competition, which might be regarded as his/her worst sports experience [1]. Thus, it is not uncommon for elite athletes to present performances below expectations. The term 'choking' has been used to describe such a phenomenon. Choking is defined as any poor or lower-than-expected performance in high-pressure conditions [2, 3]. Distraction and self-focus are two study fields used for investigating the underlying mechanism of the issue. According to the distraction model, the performer under pressure does not focus on the stimuli related to the task [4]. In addition, in the self-focus model, it is assumed that the performer under pressure takes some kind of internal focus [5].

Most studies devise a combination of different factors such as audience, competition, awards, and video cameras to create pressure [4]. Few studies have examined the effect of pressure in different conditions. Zhao (2024) examined the choking under pressure in elite recurve archery. Their results showed that pressure can substantially reduce an athlete's performance in the final arrow they shoot in each set by comparing their performance in low-stakes (first two shots) and high-stakes scenarios (final shot) [6].

Hill and Mesagno (2023) examined the choking under pressure in golf. Their results showed that golfers within the study who experienced highly destructive consequences, by engaging in brooding rumination shortly after choking and appraising the event negatively/self-critically [7].

But, the present study, similar to the research conducted by DeCaro et al. (2011), examines the effect of separate pressure conditions. They believe that high-pressure conditions have various components that are likely to have different effects; and this may lead to explicit monitoring, distraction, or both. The researchers studied the effects of two types of pressure: *monitoring pressure* and *outcome pressure*. Their prediction was that being seen by others or using a camera might increase attention to skills or processes (monitoring pressure) versus the pressure of offering an award or achieving a goal may convey a person's attention to the condition or results (outcome pressure). According to the results of DeCaro et al. (2011), the performance of players during monitoring pressure and decision-making under outcome pressure is destroyed [8].

Decision-making plays a vital role in sports-related activities, and the associated processes are directly related to the failure or success of players [9]. In sports, decisions are often made under pressure conditions. Hence, various researchers have examined the effects of pressure conditions on decision-making.

Almonroeder et al. (2020) examined the influence of fatigue on decision-making in athletes. The results indicated that fatigue may compromised an athlete's cognitive processing in a manner that diminished their ability to control movement when rapid decision-making is required [10].

Gantois et al. (2020) examined the effect of mental fatigue on passing decision-making in professional soccer athletes. The Game Performance

Assessment Instrument (GPAI) analysis showed impaired passing decision-making performance following the 30-min Stroop task compared with the 15-min and control condition. Moreover, an increase in response time during the Stroop task was found following 30-min Stroop task condition compared to 15-min of Stroop task and control conditions [11].

Parkin and Walsh (2017) examined decision-making under mental pressure in young elite athletes. They showed that decision-making speed decreased when there was a mental stress [12].

Based on the existing evidence, decision making is closely related to several factors and perception one of the most important ones. Today, some research studies conducted on decision-making and perception are focused on using tracking skills and visual search to assess players' visual perception during decision making [13, 14].

Athletes' visual search in under-pressure conditions is one of the favorite topics, reporting conflicting results on the effect of tension on eye movements. Arab et al. (2023) examined the effect of arousal on eye movements of professional volleyball players. Their results showed that the number of visual fixations and the duration of visual fixations increased [15].

Murray et al. (2024) examined gaze control and tactical decision-making under stress in active-duty police officers during a live use of force response. Their results showed that the duration of visual fixations increased [16].

Runswick et al. (2018) examined the effect of anxiety and the condition-specific context on perceptual-motor skills. Their results showed that the average number of visual fixation increased under conditions of high anxiety [17].

Under pressure conditions in sports are one of the areas of interest for researchers. In other hand, one of the factors influencing the success of soccer players is their visual perception and making the right decisions in under pressure conditions. According to the researchers of the present study, few studies has examined the decision-making and visual search behavior in under pressure conditions simultaneously in soccer players so far. In addition, due to the contradictions in the study of choking caused by distraction and self-focus in cognitive tasks such as decision-making, the present study seeks to investigate the effect of under pressure conditions on decision-making and visual search behavior of soccer players.

2. Materials and Methods

2.1. Participation

The statistical population of the present study consisted of all male soccer players (age range: 13-16 years) of Tehran Premier League in Iran and 18 players were selected as the sample. All players participated in this research voluntarily and their consent forms were filled and approved by their parents. The project was approved by the Ethics Committee on Research with Human Beings of the University of Tehran (IR.UT.SPORT.REC.1397.020).

2.2. Instrument

Perceived pressure. A person's perception of the pressure they are experiencing is called perceived pressure. After each condition participants were asked to rate how much pressure they felt they were under on a 7-point Likert-type scale anchored by 1 (no pressure) and 7 (extreme pressure) [18].

Competitive state anxiety inventory-2 (CSAI-2). In the present study, the alternative CSAI-2, which is a

multidimensional construct, was used. This list contains 17 questions and 3 subscales including physical anxiety (e.g.: I feel tremors in my muscles), cognitive anxiety (e.g.: I'm worried about disappointing others), and confidence (e.g.: I'm pretty sure I'll do better). Physical anxiety is composed of 7 questions and the remaining 5 scales contain 5 questions. The validity of this inventory has been determined to be more than 0.7 and its reliability to be 0.80. [19].

Soccer decision-making conditions simulator. The decision-making tool for the present study designed by Zoudji, Thon & Debu in 2010 [20]. The decision-making conditions simulator included 60 images of soccer situations in the penalty area displayed on the monitor, and in each image, according to the position of the defenders and attackers, the player owning the ball should decide one of the options: pass to a teammate, shot on goal, or dribble the defender by pressing the relevant button on the keyboard. For this reason, these images were programmed and designed as software so that the results of each subject including the duration of the image display (decision speed), selection of the answer, correct and incorrect answers (decision accuracy) could be recorded automatically according to the program at the end of the test [21] (Figure 1).

Eye tracking device. Ergoneers Eye Tracking (Dikablis Professional Wireless; ERGONEERS, Germany) was used. This device recorded the gaze point at 60 Hz. This system was equipped with a camera and a recording device. The data sent as video via wireless to the computer with connection capability. In order to record the movements and changes of the eyes, the DLab software and the information processing system made by this company were used (Figure 2).

Figure 1. An example of images in decision-making simulator

Figure 2. Ergoneers eye tracking

2.3. Procedure

Upon arrival in the laboratory, parents of participants gave written informed consent and filled out a basic questionnaire on demographic information. After this, the subjects sat in a chair in front of the screen, they were told that the purpose of the test is to assess the quality of their decision-making by responding to simulated soccer conditions. The whole experiment was divided into four blocks, which included one familiar block and three test blocks. First, the simulated images of the familiarization phase included 10 images. Then, in the first block, simulated images were presented in 60 attempts (images) without pressure. Prior to the implementation of each of the following blocks, the desired interventions were applied to create the pressure, and the subjects performed 60 attempts (images) under outcome pressure in the second block and 60 attempts (images) under monitoring pressure in the third block.

In order to eliminate the effect of the order, half of the participants were first subjected to monitoring pressure and the other half were initially subjected to outcome pressure. Immediately after each block, CSAI-2 was given to the subjects and the perceived pressure scores were recorded. Before starting each block, the subjects were requested to complete the task with maximum speed and accuracy.

2.3.1. Pressure interventions

Monitoring pressure. To create such a condition, subjects were requested to perform their skills in the presence of two people. The subjects were told that these two people were analyzing how they made their decision. A camera was also placed to record all movements of the subject. Subjects were told that a recorded video of their performance would be sent to two national team coaches to rate the cognitive ability of their decision-making process compared to other subjects [18].

Outcome pressure. In this condition, the subjects were told that the scores of their performance in the previous block were not satisfactory and the scores should be increased by 20% in order to reach higher than average scores. It was also said that 300,000 Iranian Rial would be paid for acceptable scores. Also, they were told that the top three scores would receive a special prize of 1,000,000 Iranian Rial [18]. At the end, the researchers thanked all the subjects and presented gifts to them for their participation in the research.

2.4. Statistic

Descriptive statistics (mean and standard deviation) were used to describe the condition of the group. Shapiro-Wilk test was used to determine the normal distribution of the data. ANOVA with repeated measures was used to examine the effect of monitoring pressure, outcome pressure, and neutral pressure on anxiety, decision-making, and visual search. Then, Bonferroni post hoc test was used for pairwise comparison of pressure in anxiety, decision-making, and visual search behavior. The significance level in all tests was determined to be $P \leq 0.05$ and the data analysis was performed using SPSS version 21 and Microsoft Excel 2021.

3. Results

3.1. Competitive state anxiety

Results of repeated measures ANOVA test showed that the mean of cognitive anxiety ($F_{(2,\ 51)}= 6.84$, $P= 0.002$, $\eta^2= 0.21$) was significantly affect in all three conditions of neutral, monitoring, and outcome pressure, but physical anxiety ($F_{(2,\ 51)}= 25.09$, $P= 0.11$ $\eta^2= 0.08$) did not show a significant difference. The results of Bonferroni post

hoc test in Figure 3 showed that the mean of cognitive anxiety was significantly higher under outcome pressure (10.27±3.00) compared to the neutral condition (7.33±1.78; *P*= 0.03) and under monitoring pressure (9.83±2.77) compared to neutral pressure (7.33±1.78; *P*= 0.01).

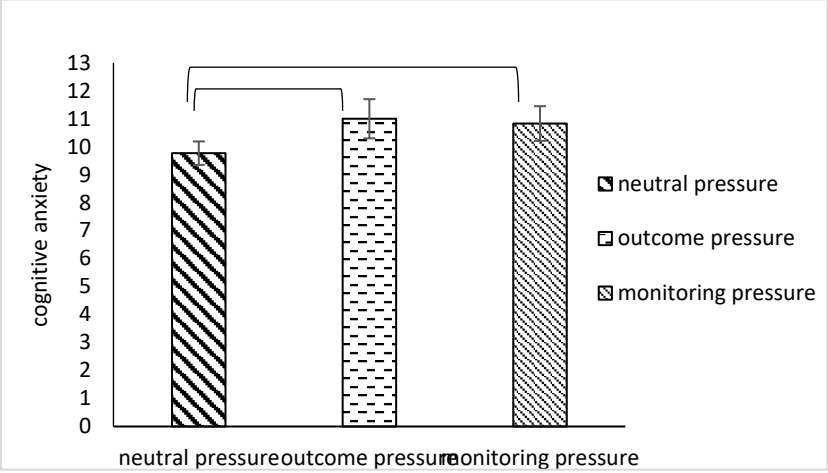

Figure 3. Comparison of mean cognitive anxiety in different pressure conditions; values represent the mean ± mean standard error in different pressure conditions (*$P \leq 0.05$, ** $P \leq 0.01$)

3.2. Decision- making

The results of repeated measure ANOVA test showed that the average speed of decision-making ($F_{(2, 34)}$= 12.07, P<0.001, η^2=0.41) and decision accuracy ($F_{(2, 34)}$= 25.09, P<0.001, η^2=0.59) were significantly affect in all three conditions of neutral, monitoring, and result pressures. The results of Bonferroni post hoc test in Figure 4 showed that the mean decision-making speed significantly declined under outcome pressure (6.22±0.92) compared to neutral conditions (5.41±0.62; *P*=0.007) and under control pressure (6.12±0.70) compared to neutral pressure (5.41±0.62; *P*=0.02). Also, according to Figure 5, the average accuracy of players' decision-making was significantly higher under outcome pressure (45.88±3.28) compared to neutral condition (42.27±2.78; *P*=0.002) and under monitoring pressure (47.16±3.01) compared to neutral pressure (42.27±78 2.78; *P*<0.001).

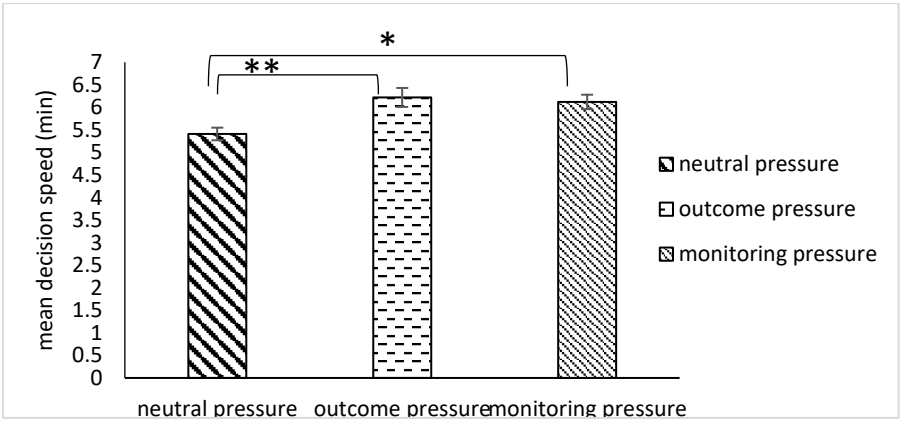

Figure 4. Comparison of mean speed of decision-making in different pressure conditions; values represent the mean ± mean standard error in different pressure conditions (*$P \leq 0.05$, ** $P \leq 0.01$)

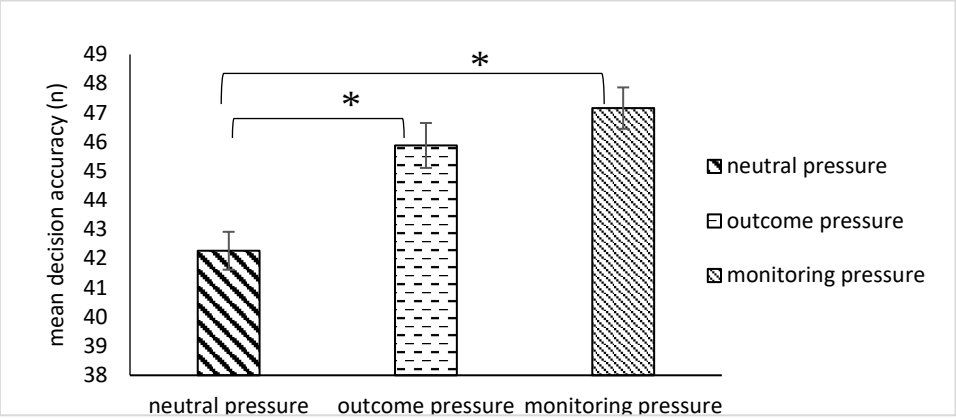

Figure 5. Comparison of mean accuracy of decision-making in different pressure conditions; values represent the mean ± mean standard error in different pressure conditions (**P≤0.01, *** P≤0.001)

3.3. Visual search behavior

The results of repeated measures ANOVA test showed the mean number of eye fixation ($F_{(2, 34)}$= 29.32, P<0.001, η^2=0.63) and the average duration of eye fixation ($F_{(1/21, 20/63)}$= 52.57, P<0.001, η^2=0.75) are significantly affect in all three conditions of neutral, monitoring, and outcome pressures. The results of the Bonferroni post hoc test in Figure 6 showed that the mean number of eye fixations significantly increased under outcome pressure conditions (5.00±1.26) compared to the neutral condition (3.45±0.9; P=0.001) and under the monitoring pressure condition (5.09±0.28) compared to neutral pressure (3.45±0.9; P=0.002). Also, according to Figure 7, the mean fixation time of the eye was significantly high under outcome pressure (2020±460) compared to neutral condition (1550±380; P=0.005) and under monitoring pressure condition (2030±410) compared to neutral pressure (1550±380; P=0.004).

4. Discussion

The purpose of this study was to investigate the effect of under-pressure conditions on decision-making and visual search behavior of soccer players. The results showed that awarding prizes (outcome pressure) and the presence of two observers and a video camera (monitoring pressure) increased the cognitive anxiety of soccer players. DeCaro et al. (2011) [8], Belle tier et al. (2015) [21] and Mesagno et al. (2011) [1] also reported the same results in their studies. However, physical anxiety did not change significantly under-pressure and rejected our hypothesis about the effect of under-pressure conditions on physical anxiety. It may be due to the fact that players were not be able to reflect their emotions through the questionnaire.

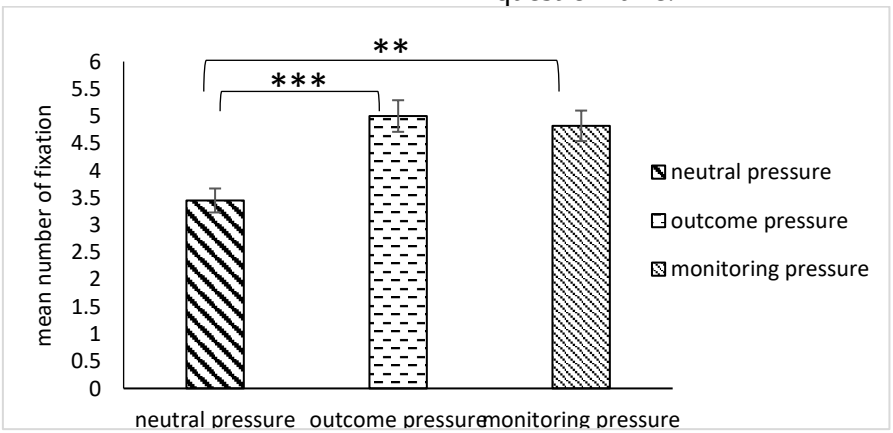

Figure 6. Comparison of average number of eye fixation in different pressure conditions; values represent the mean ± mean standard error in different pressure conditions (**P≤0.01, *** P≤0.001)

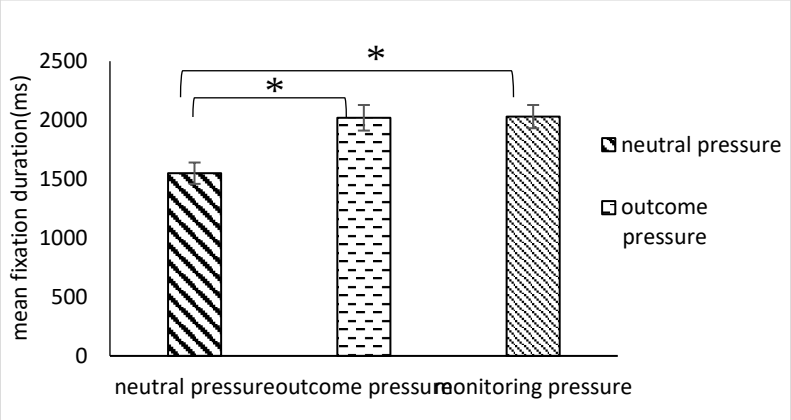

Figure 7. Comparison of mean time of eye fixation in different pressure conditions; values represent the mean ± mean standard error in different pressure conditions (**$P \leq 0.01$)

On the other hand, the subjects of this study, despite their young age, had experienced championship or higher stages of the competition, played for selected teams, performing their skills in the presence of teammates, coaches, and spectators. Therefore, this form of intervention (merely cognitive), which was probably related to the actual conditions of a competition (a motor-cognitive task), is the reason for the lack of significant differences in physical anxiety in different pressure.

Also, the results of this study showed that the average speed and accuracy of decision-making of players in three conditions of neutral (no pressure), outcome pressure, and monitoring pressure were significantly different. Compared to neutral pressure condition, the average speed decreased and the accuracy of decision-making increased significantly in outcome and monitoring pressures. In order to have the best performance, players had to make the fastest and most accurate decisions in under-pressure conditions, but the results showed that decision-making in under- pressure conditions was disrupted. Based on accuracy-speed trade-off during the decision-making task, players may choose between speed and accuracy and perform the task more quickly and less accurately, or more accurately and less quickly [22]. This might be more apparent when players want to make decisions under-pressure conditions or they prefer to choose accuracy over speed in outcome pressure and monitoring pressure conditions. Therefore, the accuracy and speed of decision-making increased and decreased, respectively.

Also, the outcome pressure, which was created by providing unrealistic feedback (saying that your performance in the previous stage was lower than expected) and encouraging the player to reach the goal and reward, probably put the player in a condition where he wanted to win prizes and be one of the top players; so he had to reduce the number of his wrong decisions and pay more attention to his decision-making, which is why he neglected speed. Monitoring pressure, which was created due to the presence of two observers and a video camera, probably created conditions for the player to try harder to make fewer wrong decisions for the fear of negative evaluation by experts; so he spent more time on his decisions; which in turn prolonged the time of decision-making.

Further, Parkin and Walsh (2017) examined cognitive pressure in young elite

athletes and showed that decision-making speed decreased in pressure conditions [12]. Vater (2014) examined the effect of anxiety on decision-making and visual search behavior in complex sports conditions; the results showed that in high-pressure conditions, decision-making speed decreased [23]. The results of these two studies were consistent with those of the present study.

On the other hand, Arab et al. (2023) examined the effect of arousal on decision making of professional volleyball players; the results showed that the speed of decision-making increased, and the reason for this inconsistency is probably due to the different sports field of the participants in the research, the form and nature of the skills that were used [15].

Kinrade et al. (2015) conducted a study on reprocessing, task complexity, and under-pressure decision-making in basketball. They used a perceptual judgment task, including simulated basketball videos. Their results showed that under high-pressure, decision-making speed is maintained and decision-making accuracy is reduced [18].

Nieuwenhuys et al. (2012) examined the tendency of police officers to shoot in anxious conditions in a simulated shooting task. Their results showed that under high pressure, the speed of decision-making increased but accuracy decreased [24]. The mentioned studies were inconsistent with our results.

In the study by Kinrade et al. (2015), the reason for the discrepancy with the results of the present study was that they simultaneously examined the effect of complexity on the task. Also, the pressure they applied was a combination of both outcome and monitoring pressures [18].

The present study examined these two pressures separately, and the sport, the age of the subjects, and the task were different in the present study. The results of Nieuwenhuys et al. (2012) [24] were inconsistent with the present study due to the differences in simulated task, field of sport and novice athletes, different pressure conditions, sex, and age of the subjects.

The results of the present study showed that the mean number of eye fixations and the average duration of eye fixation in three conditions of neutral (no pressure), outcome and monitoring pressures during decision-making in soccer were significantly different. In other words, the average number of fixations along with the average duration of fixations in outcome and monitoring pressures during decision-making increased significantly compared to the neutral pressure condition. In general, it has been found that visual search behavior changes under-pressure conditions. Contrary to popular belief, experiencing anxiety caused by stressful conditions does not always have negative effects [25].

There are many cases in which, despite reports of high levels of anxiety and change of visual control, athletes can reach and maintain high levels of performance [26]. In a study, Arab et al. (2023) examined the effect of arousal on eye movements of professional volleyball players. Their results showed that the number of visual fixations and the duration of visual fixations increased [15].

Murray et al. (2024) examined gaze control and tactical decision-making under stress in active-duty police officers during a live use of force response. Their results showed that the duration of visual fixations increased [16].

Nieuwenhuys et al. (2008) examined the effect of tension on perceptual-motor function in a simulated shooting task. They

showed that as tension increased, the number and duration of visual fixations on the opponent's head and weapon increased [27]. The results of the above studies are consistent with results of the present study.

Wilson et al. (2009) studied the effect of anxiety on controlling visual attention in a free throw in basketball. Their results showed that in tension conditions, the fixation time was shorter and as a result, the player's performance was impaired [28]. These results were inconsistent with the results of the present study, which may be due to differences in the sport field, the type of task, the number of samples, and their skill levels. Furthermore, they only used financial rewards and competitive conditions to impose pressure on the players, while in the present study, in addition to rewards and incentives to achieve high rankings, two observers and video cameras were also used.

Moreover, there are different theories and models in explaining the different effects of under-pressure conditions on visual control mechanisms. Based on the distraction model, the players under outcome pressure do not pay attention to the stimuli related to the task in order to win the prize. As a result, the individual's performance is impaired [29].

The theory that is consistent with the model of distraction is attentional control theory (ACT). According to this theory, high-pressure conditions lead to a change in goal-oriented control and attention to strategy, resulting in decreased performance [30]. Therefore, it can be said that in the present study, the players under outcome pressure (which is created through awarding and reaching a performance standard) spend more time for visual search to make appropriate decisions compared to neutral pressure condition due to the increased amount of processed information and lack of attention to the main information of the task.

Also, in the self-focus model, it is assumed that the performer under pressure receives some kind of internal focus. Here, there are two approaches too. Self-awareness theories assume that increasing pressure increases self-awareness [5] and one aware of the difference between the standard performance and one's actual behavior and performance. This awareness of difference causes the player increases the comparison between standard and actual performance. These repeated comparisons take time and therefore lead to poor performance (either due to slow performance or incorrect choice of movement).

The second approach, explicit monitoring, points out that the performer under pressure tends to show his/her best performance, which leads to a focus on the process of performance [3]. Therefore, based on the self-focus model, it can be said that in the present study, players under monitoring pressure (created through the presence of two evaluating instructors as well as video cameras), in comparison to neutral pressure, spent more time for visual search to make appropriate decisions due to repeated comparisons between their standard performance and their actual performance. Also, due to explicit monitoring, players tended to perform at their best; so their focus on the performance process was reduced, and to compensate for that, they used more visual control mechanisms than neutral (no pressure) pressure conditions.

5. Conclusions

In general, the results of the present study emphasize the effect of under- pressure

conditions on the speed and accuracy of decision-making and visual search behavior in simulated soccer conditions. Instead of making quicker and more accurate decisions, under-pressure soccer players exchanged speed-accuracy trade-off and showed better accuracy by reducing their speed. Also, soccer players change their visual control mechanism under pressure so that their performance is less likely to decline. Therefore, soccer coaches are suggested to create psychological pressure conditions during training sessions and ask players to see with better concentration and attention, and to decide more quickly and accurately so that they can better overcome the challenges in competition conditions.

One of the limitations of this study is that due to the reduction of noise and errors in the visual tracking device, which is usually created in motion, we had to design a task the player could perform with less movement to provide more accurate and better data on the output; this might be a little different from the reality of soccer, which is more about movement and cognition (not just cognition). Also, the age range of the subjects was 13-16 years. The results of this study may not be generalized to older age groups due to psychological changes and coincidence with the onset of puberty. The main strengths of this study include the use of valid instruments with accurate measurement in visual tracking, the use of within-group comparison to reduce the effect of intergroup differences, and the use of counterbalance to reduce the order effect in different stressful conditions. Therefore, in future studies, it is suggested to use wireless visual tracking devices to evaluate the players' decision-making performance in more realistic competition conditions and movements. Also, due to the importance of neural mechanisms involved in decision making and emotion control, it is suggested that future studies use such tools as EEG and fMRI for more detailed and studies.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

The author contributed to the original idea, study design.

Ethical considerations

The author has completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

The project was approved by the Ethics Committee on Research with Human Beings of the University of Tehran (IR.UT.SPORT.REC.1397.020).

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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