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Section IV – Psychological and Sociological Aspects of Sport and Exercise

With or Without a Goalkeeper: Visual Strategies and Performance in Soccer Penalty Kicks

by

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This study investigated how goalkeeper presence and behavior influenced visual attention, oculomotor responses, and penalty performance in soccer players of different expertise levels. Twenty male players (amateur: n = 9; elite: n = 11) each performed twenty-four penalty kicks under four different conditions: no goalkeeper (C1), a moving goalkeeper naive to shot direction (C2), a moving goalkeeper informed of shot direction (C3), and a stationary goalkeeper positioned centrally without attempting to save (C4). Eye movements were recorded using an eye tracker to measure fixation duration, the count, and pupil size across successful and unsuccessful kicks for all conditions. A mixed-design ANOVA revealed significant main effects of the goalkeeper condition ($p < 0.001$), the area of interest ($p < 0.001$), and the group ($p < 0.05$) on fixation duration, as well as a significant condition × group interaction ($p < 0.01$). Elite players exhibited longer fixation duration and distinct fixation-count patterns compared with amateurs, especially under goalkeeper-present conditions (C2–C4), reflecting superior attentional stability and cognitive efficiency. Pupil size was significantly larger in goalkeeper-present conditions than in the no-goalkeeper condition ($p < 0.05$); however, pupil size remained consistent across groups. Moreover, unsuccessful kicks were associated with greater pupil dilation and, in specific comparisons, longer fixation duration, indicating greater attentional demands. A significant three-way interaction (group × condition × direction, $p < 0.05$) demonstrated that visual strategies and performance outcomes were dynamically shaped by contextual constraints and the skill level. Findings provide converging evidence that goalkeeper presence modulates perceptual-cognitive control during penalty kicks. Integrating goalkeeper-based scenarios in training may enhance players' gaze behavior, decision-making, and execution accuracy under competitive conditions.

***Keywords**: eye movements; visual attention; fixation; pupil size; team sports*

Introduction

Soccer is one of the most widely played and followed sports globally, with match outcomes often determined by goal differentials. Among the various factors influencing results, penalty kicks hold particular importance, especially in high-stakes tournaments and knockout stages where matches are frequently decided through shootouts (Schaflechner et al., 2024). The successful execution of a penalty kick is closely tied to a player's technical proficiency, psychological resilience, and decision-making under pressure (Ellis and Ward, 2022). Given the increasing number of matches determined by penalties, researchers have sought to identify the key determinants of penalty performance (Jamil et al., 2020; Luis-del Campo et al., 2024; Maneiro et al., 2026). Statistical analyses of international competitions further highlight the decisive role of penalties. Since the introduction of group-stage play in the UEFA European Championship in 1980, 216 matches have been played, resulting in 518 goals, of which 37 were scored from penalties. Similarly, across five recent Champions League seasons (2018/2019–2022/2023), 243 penalties were awarded, with a high overall conversion rate, especially for shots aimed at the center and upper areas of the goal

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(Schaflechner et al., 2024). These figures underscore the need to investigate penalty strategies and the factors influencing success rates. Beyond technical execution, strategic decision-making plays a critical role in penalty success. Research distinguishes between two main strategies: the goalkeeper-independent (open-loop) and the goalkeeper-dependent (closed-loop) approaches (van der Kamp, 2011). In the former, players select a target before the shot and remain committed to it, disregarding the goalkeeper's movement (Navarro et al., 2013). This strategy has been shown to be particularly effective under high-pressure conditions (Wood and Wilson, 2012). By contrast, the goalkeeper-dependent strategy requires players to observe the goalkeeper's movement before deciding on shot direction (van der Kamp and Masters, 2008). However, this approach is often less successful, as it reduces execution time and increases susceptibility to last-moment errors (Noel and van der Kamp, 2012).

Perceptual-cognitive processes have been highlighted as playing a critical role in the execution of penalty kicks. One fundamental component of these processes is visual search, which is defined as a cognitive mechanism through which individuals extract task-relevant information from complex environments via gaze behaviors such as fixations and saccades (Guo and Wang, 2025). Visual attention is a critical determinant of successful performance across diverse tasks, with strong evidence linking focused gaze and attention strategies to improved outcomes in sports, skilled activities, and cognitive tasks (Jin et al., 2020; Popowczak and Zwierko, 2025; Zemkova et al., 2025). Eye-tracking research has further demonstrated that fixation duration, fixation count, and gaze stability significantly influence penalty accuracy (Piras and Vickers, 2011). Recent technological advances allow researchers to expand this line of inquiry by examining not only these visual-cognitive processes but also physiological indicators. In particular, pupil size has emerged as a reliable marker of attentional engagement and emotional arousal; fluctuations in pupil size during high-pressure tasks such as penalty kicks have been associated with cognitive load, stress levels, and decision-making efficiency (Bradley et al., 2008; Eckstein et al., 2017). Decision-making is the ability to select and execute the appropriate action based on the current circumstances on the field of play, as well as the demands of the game strategically and tactically (Baker et al., 2003). In the context of sports, this process is referred to as sport decision-making, which is defined as the comprehensive process by which athletes perceive, interpret, analyze, and respond to information in dynamic competitive environments (Yunchao et al., 2023). Larger pupil size reliably signals increased mental effort and sympathetic activation, reflecting heightened focus, arousal, or stress (Gorin et al., 2024).

A recent study has successfully identified technical, tactical, and physical predictors of match outcomes using machine learning approaches (Oliva-Lozano et al., 2025); less is known, however, about the perceptual-cognitive mechanisms underpinning these performance indicators, particularly in high-pressure situations such as penalty kicks. Integrating pupillometry with gaze behavior thus provides a more comprehensive understanding of perceptual-cognitive demands in soccer. Building on this framework, the present study aimed to investigate the eye movement strategies employed by amateur and elite soccer players during penalty kicks under varying experimental conditions. The study specifically aimed to investigate how the goalkeeper's presence (i.e., no goalkeeper, naive goalkeeper, knowledgeable goalkeeper, stationary goalkeeper), fixation location (right, left, the ball and the goalkeper), eye movement metrics (fixation count, duration and pupil size) affected penalty performance. It was hypothesized that significant differences in penalty performance would emerge between amateur and elite soccer players, and that these differences would vary according to the goalkeeper condition and the fixation location. Furthermore, oculomotor variables such as fixation duration, the fixation count, and pupil size were expected to differ according to the expertise level, reflecting variations in perceptual-cognitive processing. Finally, it was anticipated that the presence and behavior of the goalkeeper would shape visual attention strategies, functioning as indicators of cognitive load and emotional arousal through gaze patterns and pupillometric response. The findings of this study were expected to contribute to the sport science literature by clarifying the perceptual-cognitive mechanisms underpinning

successful penalty performance. By integrating oculomotor measures with performance outcomes, this research aimed to provide evidence-based insights for training interventions designed to optimize gaze behavior, attentional control, and stress regulation in high-stakes scenarios. Furthermore, by linking physiological indicators of cognitive load with contextual game factors, the study offers a more comprehensive model of athletes' behavior during critical performance situations.

Methods

Participants

Using G*Power version 3.1.9.4, an a priori power analysis was conducted to calculate the necessary sample size. Assuming $\alpha = 0.05$, power = 0.95, effect size $f = 0.4$ (Vater et al., 2017), two skill-level groups, four repeated measures, and an inter-measure correlation of $r = 0.5$, the analysis indicated that at least 16 participants were required. Consistently with Bekris et al. (2018), players at the national level were defined as elite (n = 11: mean age of 17.09 ± 0.53 years, mean body height of 178.45 ± 6.37 cm, mean body mass of 69.27 ± 4.77 kg, and mean training experience of 9.18 ± 0.75 years), and those at the regional level as amateurs (n = 9: mean age of 17.11 ± 0.78 years, mean body height of 175.44 ± 5.07 cm, mean body mass of 67.55 ± 9.23 kg, and mean training experience of 5.11 ± 0.78 years). A total of 20 male soccer players voluntarily participated in this study. Prior to testing, ethical approval was obtained from the Ethics Committee of the Eskisehir Technical University, Eskisehir, Turkey (protocol code: 98971; approval date: 26 December 2019) and the study was conducted in accordance with the Declaration of Helsinki. Participants voluntarily provided written informed consent and were fully briefed regarding the experimental procedures, potential risks, and benefits.

Measures

Penalty kicks were performed according to FIFA regulations (IFAB, 2022/2023), including official goal dimensions (width: 7.32 m; crossbar height: 2.44 m), penalty spot distance (11 m), and ball specifications (circumference: 68–70 cm; mass: 410–450 g; pressure: 0.6–1.1 bar). Two orange PVC canvases (1.8 m wide × 1.6 m high) were positioned in the upper corners of the goal, each with a black target (22 cm in size) centered on the canvas (Figure 1).

During the experimental procedure, participants' eye movements and visual search behaviors were continuously recorded using the Tobii Pro Glasses 2 (Tobii AB, Sweden). This system provides high-resolution binocular gaze tracking. The device was securely affixed to participants' heads with adjustable straps to minimize movement artifacts without restricting natural head or body movements. Measures were implemented to guarantee that the equipment did not compromise kicking technique or balance performance.

Anthropometric measurements were obtained using a fixed stadiometer (Holtain Ltd., UK) for body height and a bioelectrical impedance device (Tanita MC 180 Multi Frequency BIA, Japan) for body mass. Ball speed and the impact location were recorded simultaneously using three digital video cameras (GoPro HERO4 Black Edition, GoPro Inc., USA; 1080p resolution, 120 fps), positioned 1 m behind the penalty spot, 1 m laterally, and within the penalty area. The cameras were synchronized prior to data collection to ensure precise temporal alignment across recordings.

Design and Procedures

Participants performed penalty kicks under four experimental conditions: (1) no goalkeeper present (a "no goalkeeper" condition = C1), (2) a moving goalkeeper unaware of the shot direction (a "naive goalkeeper" condition = C2), (3) a moving goalkeeper informed of the shot direction prior to execution (a "knowledgeable goalkeeper" condition = C3), and (4) a stationary goalkeeper positioned at the center of the goal without attempting to save (a "stationary goalkeeper" condition = C4). Each participant executed six penalty shots per condition, resulting in a total of 24 penalty kicks. To minimize learning and fatigue effects, shots were divided into two blocks with a 5-min rest interval in between. Shot directions were evenly distributed between left and right target areas and randomized across trials. For each condition, participants performed 3 shots to the right and 3 shots to the left.

Each participant was tested individually. Anthropometric measurements were obtained in the morning prior to testing, with participants

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fasting and wearing appropriate clothing. Body height was measured in an anatomical position, and body mass was measured using a bioelectrical impedance device.

Participants then completed a standardized warm-up routine to prepare physically and reduce injury risk. The warm-up included 10 min of light jogging at self-selected pace, followed by 1 min of walking to facilitate recovery, and 10 min of dynamic and static stretching targeting major muscle groups to enhance flexibility and range of motion relevant to soccer-specific movements.

Prior to shooting, the eye-tracking system was fitted and calibrated for each participant using built-in calibration cards and a suitable nose pad to ensure precise mapping of gaze data. Participants were instructed to aim at the designated targets on the upper corners of the goal. To familiarize participants with the setup and reduce learning effects, they completed five supervised practice penalty kicks.

During the procedural briefing, participants were informed about the independent strategy, which involved ignoring goalkeeper's movements when executing penalty kicks. They were instructed to strike the ball with sufficient force (~22 m/s) to challenge the goalkeeper (Graham-Smith et al., 1999). In the "naive" and "knowledgeable" goalkeeper conditions, goalkeepers were instructed to attempt a save but not initiate movement until approximately 250 ms before foot-ball contact (Lees and Owens, 2011). Goalkeepers maintained a standardized stance before each trial, with knees slightly bent, arms at the sides, and hands positioned in front at the goal center (van der Kamp and Masters, 2008).

Data Pre-Processing

Participants' gaze behavior was analyzed using Tobii Pro Lab Software (version 1.102). A total of 480 penalty kicks (24 per participant) were included in the analysis. The areas of interest (AOI) were defined as the goalkeeper, the right target area, the left target area, and the ball. The fixation count (FC) was operationalised as the number of fixations within each AOI, while fixation duration (FD) was defined as the duration of fixations within each AOI (Casanova et al., 2022).

Fixation locations, duration, and the number of fixations were analyzed from the onset of the visual stimulus until ball contact, encompassing the preparation, approach, and ball contact phases of the penalty kick. Pupil size was analyzed separately across three distinct time windows: baseline (1000 ms prior to the stimulus onset, corresponding to the preparation phase), online/execution (from the stimulus onset to ball contact, covering the preparation, approach, and ball contact phases), and follow-through (the 1000-ms period immediately after the ball contact). To control for luminance effects on pupil size, all measurements were conducted under consistent lighting conditions in the same sports hall for all participants.

Statistical Analysis

Penalty kick performance was assessed using written notes and video recordings, classifying each kick as successful (hitting/reaching the target) or unsuccessful (missing/hitting the post). Visual attention, based on fixation duration and the count, was analyzed across goalkeeper conditions and shot directions for elite and amateur players. A mixed-design ANOVA (2 groups [elite and amateur] × 4 conditions (no goalkeeper, a naive goalkeeper, a knowledgeable goalkeeper, a stationary goalkeeper) × 4 fixation locations [the goalkeeper, right, left and the ball]) was conducted, with Greenhouse-Geisser corrections applied when sphericity was violated. Pupil size changes were analyzed using a mixed-model ANOVA (2 groups × 4 conditions × 2 phases [online, follow-through] × 2 shot outcomes [successful and unsuccessful]), with significant effects examined via Bonferroni post-hoc tests. When a significant interaction was observed in the mixed-design ANOVA, simple effects analyses were conducted. Specifically, paired samples *t*-tests were used to compare groups at each level of the within-subjects factor. Data are presented as mean and *SD*, with normality checked using Shapiro-Wilk and Kolmogorov-Smirnov tests. Analyses were performed in SPSS (v26), with significance set at $p < 0.05$.

Results

Elite players achieved 35, 34, 32, and 32 successful shots across conditions 1–4, whereas amateurs achieved 29, 29, 28, and 34 successful shots, respectively. In terms of unsuccessful shots, elites recorded 31, 32, 34, and 34 across the same

conditions, while amateurs recorded 25, 25, 26, and 20, respectively.

Fixation Duration

Fixation duration of the athletes was significantly influenced by game conditions, as indicated by the main effect of condition for both successful ($F_{(2.84, 676.52)} = 26.33$, $p < 0.001$, $n_p^2 = 0.100$) and unsuccessful penalty kicks ($F_{(2.73, 649.48)} = 25.59$, $p < 0.001$, $n_p^2 = 0.097$). Similarly, the AOI played a crucial role, with fixation duration differing significantly across specific target areas for both successful ($F_{(1.49, 355.34)} = 80.04$, $p < 0.001$, $n_p^2 = 0.252$) and unsuccessful penalty kicks ($F_{(1.59, 378.73)} = 98.98$, $p < 0.001$, $n_p^2 = 0.294$). Furthermore, a significant main effect of the group was observed for both successful ($F_{(1, 238)} = 5.07$, $p = 0.025$, $n_p^2 = 0.021$) and unsuccessful ($F_{(1, 238)} = 4.90$, $p = 0.028$, $n_p^2 = 0.020$) penalty kicks, suggesting distinct attentional patterns between the groups (see Table 1 for descriptive values).

Significant interaction effects further clarified how game conditions impacted different participants' groups. A significant condition × group interaction was observed for both successful ($F_{(2.84, 676.52)} = 4.17$, $p = 0.007$, $n_p^2 = 0.017$) and unsuccessful penalty kicks ($F_{(2.73, 649.48)} = 3.04$, $p = 0.033$, $n_p^2 = 0.013$), indicating that the influence of game pressure on fixation duration differed according to the athletes' expertise levels. Additionally, a significant group × AOI interaction was found for both successful ($F_{(1.49, 355.34)} = 3.55$, $p = 0.043$, $n_p^2 = 0.015$) and unsuccessful penalty kicks ($F_{(1.59, 378.73)} = 3.39$, $p = 0.045$, $n_p^2 = 0.014$), showing that the groups exhibited distinct attentional patterns across target areas. All other interaction effects were not statistically significant ($p > 0.05$).

Under the stationary goalkeeper condition (C4), elite players displayed significantly longer fixation duration toward the left side when performing unsuccessful kicks ($t = 2.079$, $p = 0.040$). Under the naive goalkeeper condition (C2), the elite group exhibited significantly fewer fixations during successful kicks, both toward the goalkeeper ($t = -2.947$, $p = 0.005$) and the right directions ($t = -3.411$, $p = 0.001$). Likewise, under the stationary goalkeeper condition (C4), amateur players allocated significantly more fixations to the right side during unsuccessful kicks ($t = 2.988$, $p = 0.005$).

Post-hoc comparisons revealed significant differences across conditions. Specifically, significant differences were observed between C1 and C2 for both successful and unsuccessful trials ($p < 0.001$). Additionally, C2 differed significantly from both C3 and C4 in successful trials ($p < 0.001$), and from C4 in unsuccessful trials ($p < 0.001$). For direction, post-hoc comparisons indicated significant differences between goalkeeper and right (successful and unsuccessful: $p = 0.001$), left ($p < 0.001$), and ball ($p < 0.01$) fixation locations. Furthermore, significant differences were found between ball and both right and left directions for both successful and unsuccessful trials ($p < 0.001$). Table 2 shows the comparison of fixation duration and the number between successful and unsuccessful penalty kicks. Also, Figure 2 presents fixation duration for successful and unsuccessful penalty kicks across the conditions.

Fixation Count

ANOVA results revealed a significant main effect of the condition on the fixation count for both successful ($F_{(2.40, 127.03)} = 4.88$, $p = 0.006$, $n_p^2 = 0.084$) and unsuccessful penalty kicks ($F_{(1.91, 160.77)} = 15.66$, $p < 0.001$, $n_p^2 = 0.157$). This indicates that different game conditions significantly altered athletes' visual search behavior. For the fixation count, there was a significant main effect of the AOI for both successful ($F_{(1.64, 86.64)} = 25.66$, $p < 0.001$, $n_p^2 = 0.326$) and unsuccessful penalty kicks ($F_{(1.73, 145.11)} = 30.70$, $p < 0.001$, $n_p^2 = 0.268$). A significant main effect of the group on the fixation count was also found for both successful ($F_{(1, 53)} = 12.14$, $p = 0.001$, $n_p^2 = 0.186$) and unsuccessful penalty kicks ($F_{(1, 84)} = 7.49$, $p = 0.008$, $n_p^2 = 0.082$). These findings also suggest that expert players, compared to novices, directed more fixations toward target areas, employing visual search strategies more effectively, which might influence performance.

Regarding interaction effects, the condition × group interaction was significant for successful penalty kicks ($F_{(2.40, 127.03)} = 3.20$, $p = 0.035$, $n_p^2 = 0.057$). The group × direction interaction was significant for successful penalty kicks ($F_{(4.53, 240.26)} = 6.94$, $p < 0.001$, $n_p^2 = 0.116$). Also, the condition x direction interaction was significant for both successful ($F_{(4.53, 240.26)} = 6.94$, $p < 0.001$, $n_p^2 = 0.116$) and unsuccessful penalty kicks ($F_{(4.96, 416.62)} = 6.74$, $p < 0.001$, $n_p^2 = 0.074$). Additionally, a significant three-way interaction of condition × group × direction was found for both successful ($F_{(9, 477)} =$

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2.97, $p = 0.002$, $n_p^2 = 0.053$) and unsuccessful penalty kicks ($F_{(9, 756)} = 2.14$, $p = 0.024$, $n_p^2 = 0.025$). All other interaction effects were non-significant ($p > 0.05$).

The post-hoc comparisons for conditions revealed significant differences between C1 and C2, C2 and C3, and C2 and C4 in unsuccessful penalty kicks (all $p < 0.001$). For direction, significant differences were observed between the ball and right, left, and goalkeeper directions for both successful and unsuccessful penalty kicks ($p \leq 0.001$). Additionally, in unsuccessful penalty kicks, significant differences were found between goalkeeper and right ($p = 0.031$), goalkeeper and left ($p < 0.001$), and right and left ($p = 0.026$) directions. Table 3 presents the descriptive values of fixation counts across conditions and directions. The fixation counts for successful and unsuccessful penalty kicks across conditions are shown in Figure 3.

Pupil Size

The ANOVA performed on pupil size revealed significant main effects for the condition ($F_{(3,54)} = 5.573$, $p = 0.002$, $n_p^2 = 0.236$), the phase ($F_{(1,18)} = 327.635$, $p < 0.001$, $n_p^2 = 0.948$) and penalty success ($F_{(1,18)} = 5.00$, $p = 0.038$, $n_p^2 = 0.217$). However, the main effect of the group was not significant ($F_{(1,18)} = 2.841$, $p = 0.109$, $n_p^2 = 0.136$), indicating that overall pupil responses did not differ reliably between expert and novice players. Follow-up comparisons for conditions indicated that pupil size was significantly smaller under C1 compared to both C2 and C3 ($p < 0.05$). For the phase, post-hoc analysis revealed significant differences between online and follow-through phases ($p < 0.001$), with pupil size significantly larger during the follow-through phase than during the online phase. Regarding penalty success, post-hoc comparisons indicated a significant difference between successful and unsuccessful penalty kicks, pupil size was significantly larger during unsuccessful penalty kicks compared to successful ones ($p = 0.038$). In addition, a significant condition × group interaction was observed ($F_{(3,54)} = 2.91$, $p = 0.043$, $n_p^2 = 0.139$), indicating that the effect of condition on pupil size varied as a function of the expertise level. However, all remaining interaction effects were non-significant ($p > 0.05$).

Table 1. Descriptive values for fixation duration for both studied groups.

Variables		Successful Kicks			
		Goalkeeper	Right	Left	Ball
C1	Elite	0.00 ± 0.00	0.28 ± 0.03	0.24 ± 0.04	0.18 ± 0.03
	Amateur	0.00 ± 0.00	0.50 ± 0.05	0.22 ± 0.04	0.18 ± 0.03
C2	Elite	0.27 ± 0.04	0.11 ± 0.02	0.12 ± 0.02	0.14 ± 0.03
	Amateur	0.19 ± 0.03	0.08 ± 0.02	0.05 ± 0.01	0.08 ± 0.02
C3	Elite	0.15 ± 0.02	0.11 ± 0.02	0.09 ± 0.02	0.11 ± 0.02
	Amateur	0.12 ± 0.02	0.04 ± 0.01	0.05 ± 0.01	0.06 ± 0.01
C4	Elite	0.55 ± 0.10	0.70 ± 0.12	0.45 ± 0.08	0.35 ± 0.06
	Amateur	0.45 ± 0.08	0.65 ± 0.10	0.50 ± 0.12	0.30 ± 0.06
		Unsuccessful Kicks			
C1	Elite	0.00 ± 0.00	0.27 ± 0.04	0.23 ± 0.04	0.19 ± 0.03
	Amateur	0.00 ± 0.00	0.48 ± 0.04	0.25 ± 0.05	0.18 ± 0.03
C2	Elite	0.26 ± 0.04	0.10 ± 0.02	0.11 ± 0.02	0.15 ± 0.03
	Amateur	0.20 ± 0.03	0.10 ± 0.02	0.07 ± 0.02	0.09 ± 0.02
C3	Elite	0.16 ± 0.02	0.12 ± 0.02	0.08 ± 0.02	0.10 ± 0.02
	Amateur	0.13 ± 0.02	0.05 ± 0.01	0.07 ± 0.02	0.08 ± 0.02
C4	Elite	0.60 ± 0.12	0.72 ± 0.12	0.48 ± 0.09	0.34 ± 0.06
	Amateur	0.50 ± 0.10	0.70 ± 0.12	1.35 ± 0.20	0.25 ± 0.05

Values are presented mean ± SD. C1: no goalkeeper condition; C2: naive goalkeeper condition; C3: knowledgeable goalkeeper condition; C4: stationary goalkeeper condition

Table 2. Comparisons of fixation duration and fixation counts in successful and unsuccessful penalty kicks of elite and amateur players.

Variables		Fixation Duration							
		Goalkeeper		Right		Left		Ball	
		t value	*p* value	*t* value	*p* value	*t* value	*p* value	*t* value	*p* value
C1	Elite	-	-	0.732	0.465	0.672	0.503	1.967	0.051
	Amateur	-	-	0.000	1.000	0.319	0.750	0.023	0.981
C2	Elite	0.100	0.921	−0.282	0.779	0.000	1.000	0.053	0.958
	Amateur	0.506	0.614	−0.128	0.898	0.048	0.962	0.544	0.587
C3	Elite	0.187	0.852	−0.388	0.699	−0.789	0.431	1.811	0.072
	Amateur	0.364	0.716	−1.421	0.158	−0.996	0.322	−1.002	0.319
C4	Elite	0.828	0.409	1.362	0.176	2.079	0.040*	0.528	0.599
	Amateur	−0.815	0.417	1.000	0.320	−1.175	0.242	1.000	0.320
		Fixation Counts							
C1	Elite	-	-	1.276	0.208	−1.361	0.180	−.549	0.586
	Amateur	-	-	0.000	1.000	1.923	0.063	0.336	0.739
C2	Elite	−2.947	0.005*	−3.411	0.001*	−0.229	0.820	0.318	0.752
	Amateur	−0.900	0.375	−1.119	0.271	−0.961	0.344	−0.457	0.651
C3	Elite	−0.242	0.810	−0.078	0.938	1.469	0.149	−1.725	0.091
	Amateur	−0.758	0.454	−0.475	0.638	1.753	0.089	−0.058	0.954
C4	Elite	−1.318	0.194	1.101	0.277	0.944	0.350	1.218	0.230
	Amateur	−1.339	0.190	2.988	0.005*	0.611	0.545	−1.703	0.098

*Values are presented mean ± SD. C1: no goalkeeper condition; C2: naive goalkeeper condition; C3: knowledgeable goalkeeper condition; C4: stationary goalkeeper condition; * $p < 0.05$*

Table 3. Descriptive values for fixation counts for both studied groups.

Variables		Goalkeeper	Right	Left	Ball
		Successful Kicks			
C1	Elite	0.0 ± 0.0	1.0 ± 0.2	1.5 ± 0.3	1.1 ± 0.2
	Amateur	0.0 ± 0.0	1.6 ± 0.3	0.9 ± 0.2	0.7 ± 0.2
C2	Elite	1.3 ± 0.2	0.7 ± 0.2	0.6 ± 0.1	1.0 ± 0.2
	Amateur	1.0 ± 0.2	0.6 ± 0.1	0.4 ± 0.1	0.9 ± 0.2
C3	Elite	0.7 ± 0.1	0.8 ± 0.2	0.7 ± 0.1	0.7 ± 0.1
	Amateur	1.2 ± 0.2	0.2 ± 0.1	0.5 ± 0.1	0.4 ± 0.1
C4	Elite	2.5 ± 0.4	2.9 ± 0.4	2.2 ± 0.3	2.0 ± 0.3
	Amateur	2.0 ± 0.3	2.8 ± 0.4	1.8 ± 0.3	0.5 ± 0.1
		Unsuccessful Kicks			
C1	Elite	0.0 ± 0.0	3.0 ± 0.4	1.6 ± 0.3	1.3 ± 0.3
	Amateur	0.0 ± 0.0	2.8 ± 0.4	1.0 ± 0.2	0.8 ± 0.2
C2	Elite	1.5 ± 0.3	3.0 ± 0.5	0.8 ± 0.2	1.1 ± 0.2
	Amateur	1.2 ± 0.2	0.4 ± 0.1	0.3 ± 0.1	0.8 ± 0.2
C3	Elite	0.8 ± 0.1	0.6 ± 0.1	0.5 ± 0.1	0.6 ± 0.1
	Amateur	1.1 ± 0.2	0.3 ± 0.1	0.6 ± 0.1	0.5 ± 0.1
C4	Elite	2.6 ± 0.4	2.5 ± 0.4	2.0 ± 0.3	1.6 ± 0.2
	Amateur	2.2 ± 0.3	3.2 ± 0.5	2.0 ± 0.3	0.7 ± 0.1

Values are presented mean ± SD. C1: no goalkeeper condition; C2: naive goalkeeper condition; C3: knowledgeable goalkeeper condition; C4: stationary goalkeeper condition

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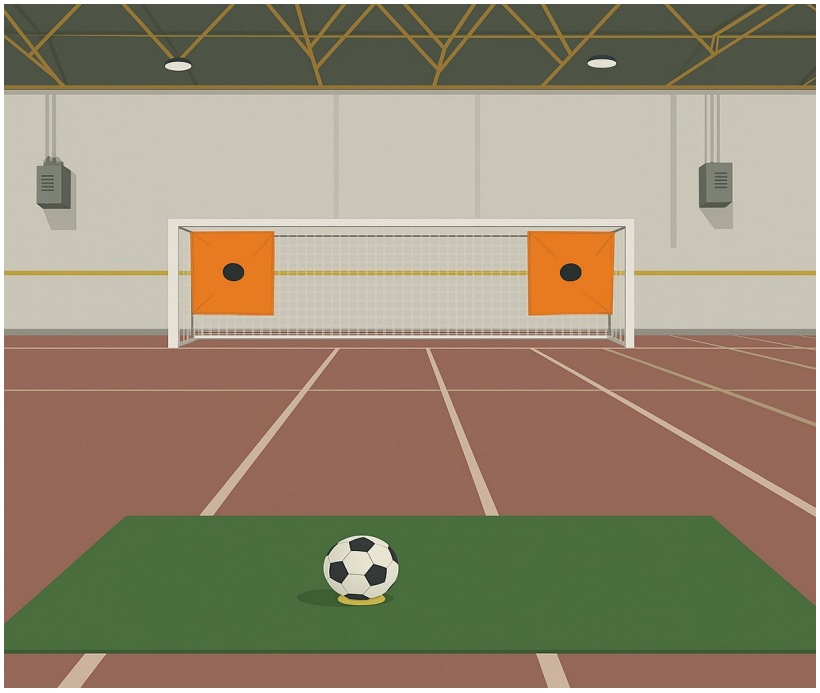


Figure 1. Experimental set-up.

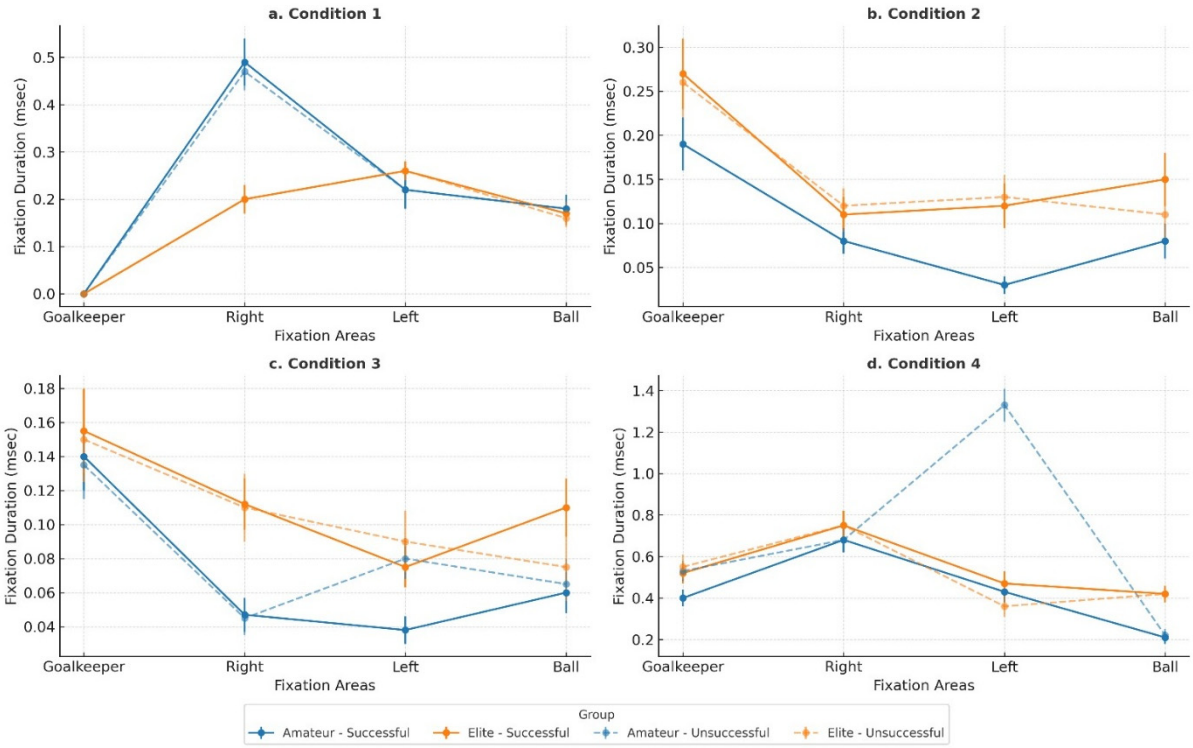


Figure 2. Fixation duration for successful and unsuccessful penalty kicks across conditions.

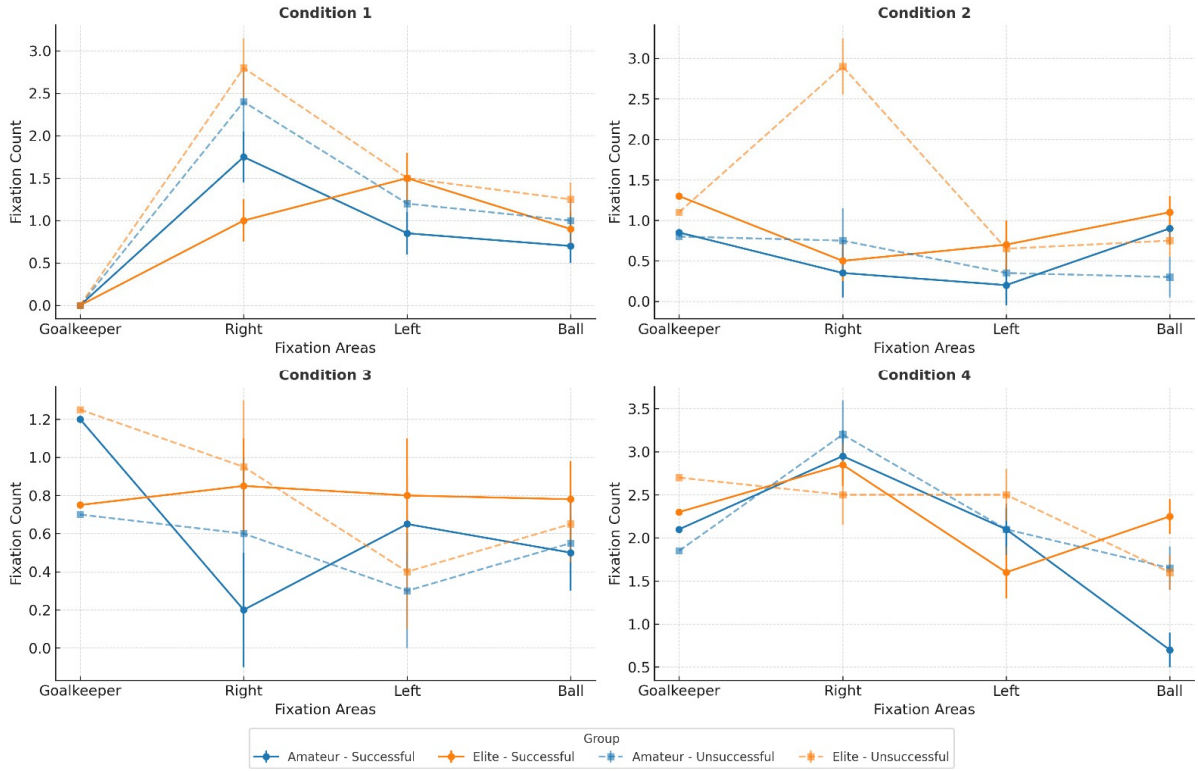


Figure 3. Fixation counts for successful and unsuccessful penalty kicks across conditions.

Discussion

Penalty kicks are considered one of the moments in which an athlete experiences the highest levels of psychological and cognitive load. During this process, how the player directs their visual attention is critically important for decision-making and motor performance. The present study aimed to examine how soccer players with different levels of experience (i.e., amateur vs. elite) employed and adapted their eye-tracking strategies across various task conditions and the fixation location during penalty kicks (successful and unsuccessful). Specifically, we sought to investigate how factors such as the goalkeeper's presence (absent, naive, knowledgeable, or stationary) and the fixation location (e.g., right, left, the ball, and the goalkeeper), as well as key eye-tracking metrics including the fixation count, fixation duration, and pupil size, interacted with players' expertise to influence visual attention, decision-making, and overall penalty performance. By analyzing these interactions, the study intended to provide insights into the perceptual-cognitive mechanisms underlying skilled performance in high-pressure soccer situations.

The main findings of the present study showed that fixation duration, the fixation count, and pupil size changed under different conditions. Furthermore, the fixation count and duration differed between groups, although pupil size did not. While it has been stated that the goalkeeper-independent strategy provides a better visual focus pattern (Noel and van der Kamp, 2012) and is better in terms of performance, it has also been noted that it is not entirely possible for the penalty taker to completely ignore the goalkeeper. Furthermore, it has been indicated that the penalty taker can be affected by the goalkeeper's movements, or even just the presence of the goalkeeper, which can lead to decreased

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performance (Navarro et al., 2013).

When we examined the pupil results, a difference between C1 and C2 as well as between C1 and C3 was observed. In other words, under conditions where the goalkeeper was present (both when the shot direction was known and unknown), there was more pupil dilation compared to the condition where the goalkeeper was absent. This result may suggest that the possibility of the goalkeeper making a save increases the players' stress levels. Indeed, pupil size expands with sympathetic activation (May et al., 2019). While no difference was detected when the goalkeeper was merely present without making a save (C4), the presence of a difference with C2 and C3 may also indicate the existence of pupil dilation, which is expected to occur as the difficulty of the task increases (Alnæs et al., 2014). However, no difference was detected between C2 and C3 in terms of pupil dilation. Although we expected greater dilation under C3 (goalkeeper knowing the intended direction), the data did not support this statistically, despite a numerical trend in that direction. This might be due to the limited sample size or to the influence of the direction factor. Considering that there are two types of penalty techniques—the goalkeeper-independent strategy (open-loop) and the goalkeeper-dependent strategy (closed-loop) (van der Kamp, 2011)—the direction specified by instruction might have been one that the athlete would not normally choose based on cues obtained from the goalkeeper's position. This situation, that is, having to take the penalty in an undesired direction, may have created additional stress for the participant. Or, it may be that simply the presence of a goalkeeper was such a stimulating factor (Navarro et al., 2013) that knowing or not knowing the direction did not create any additional stress factor.

Consistently with previous studies, no differences were observed in pupil dilation between groups of various skill levels (Campbell et al., 2019; Güler et al., 2025; Moran et al., 2016). This suggests that, regardless of expertise, the potential for goalkeeper intervention increases task difficulty for all players. Supporting this notion, UEFA Champions League statistics over 22 seasons indicate that 27.5% of penalties resulted in failure (Schaflechner et al., 2024). Thus, it seems reasonable that the possibility of a goalkeeper's save induces comparable pupil dilation across players of varying levels of experience.

Regarding successful and unsuccessful penalty kicks, the present findings demonstrated greater pupil dilation during unsuccessful than successful kicks. This pattern differs from that reported by Piras et al. (2021), who observed greater pupil dilation during correctly predicted penalties. This difference is thought to be related to cognitive load and the allocation of attentional resources. It is well established that pupil size increases in response to cognitive load (Alnæs et al., 2014; Moran et al., 2016). A recent study conducted with volleyball players also found that pupil size increased more with greater attentional processes (Nalçacıgil et al., 2025). Accordingly, unsuccessful kicks may have imposed greater cognitive demands, resulting in increased pupil dilation.

Pupil dilation was more pronounced during the follow-through phase. Following ball contact, the kicker's gaze is reoriented toward the goal to assess the outcome of the attempt, particularly to determine whether the ball reaches the intended target and adheres to the expected trajectory. This orienting response encompasses not only shifts in visual attention but also concomitant physiological and oculomotor processes, including pupil dilation, microsaccades, and saccades, which can be elicited and modulated by salient task-related stimuli (Corneil and Munoz, 2014; Wang and Munoz, 2015).

The findings indicate that both the individual expertise level and environmental conditions had significant effects on the fixation count and fixation duration. In successful shots, both condition and direction factors produced higher effect sizes on fixation duration (n_p^2 = 0.214 and n_p^2 = 0.466), suggesting that accurate kicks are associated with a more systematic and focused attentional process. Notably, elite players generally exhibited longer fixation duration compared to amateurs, highlighting their advantage in attentional control and cognitive preparation (Roca et al., 2013). Elite athletes rely on fewer but more stable fixations to guide motor actions (Mann et al., 2007). Thus, elite players demonstrate more advanced attentional control, allowing them to focus on task-relevant cues while filtering out irrelevant stimuli.

In the literature, studies comparing experts

with novices or intermediates have reported mixed findings: while some have shown that expert athletes exhibit fewer fixations of longer duration (Cañal-Bruland et al., 2011; Piras et al., 2014), others have found a greater number of shorter fixations (Roca et al., 2013; Vítor de Assis et al., 2021). Although such discrepancies may depend on task-specific demands, what is clear is that expert athletes display gaze patterns that differ fundamentally from those of less skilled performers (Heper et al., 2026; Klostermann and Moeinirad, 2020). Aksum et al. (2020), in an eye-tracking study conducted under real match conditions in the Norwegian Premier League, found that midfield players increased their fixation duration as more information sources became available. Our findings suggest that as pressure increases (C2, C3, and C4), elite soccer players may require more time to gather sufficient information before executing a penalty kick.

Previous research has reported mixed findings regarding fixation duration, with some studies showing longer fixations in successful compared to unsuccessful attempts (Klostermann and Moeinirad, 2020; Wilson et al., 2009), while others found no significant differences (Güler et al., 2024; Mann et al., 2011). In the present study, within-group comparisons between successful and unsuccessful kicks revealed that, among the elite group, fixation duration on the left AOI was significantly longer during unsuccessful kicks under C4. Similarly, when fixation counts were examined, the elite group exhibited a higher number of fixations during unsuccessful kicks on both the goalkeeper and right AOIs under C2. Furthermore, in the amateur group, a significant difference was also observed for the right AOI under C4, with unsuccessful kicks showing a greater number of fixations. No other significant differences were identified across conditions or AOIs. Overall, these findings suggest that differences in gaze behaviour between successful and unsuccessful penalties were limited and context dependent rather than systematic. The varying attentional demands imposed by the different goalkeeper conditions may have contributed to these condition-specific gaze patterns.

Limitations and Directions for Future Research

Although this study contributes to advancing the understanding of perceptual-cognitive mechanisms underlying cognitive and visual mechanisms in soccer, and represents an examination of visual focus and attentional processes under varying conditions with consideration of stress factors, several limitations should nonetheless be acknowledged. First, the relatively small sample size may have reduced statistical power, particularly in detecting subtle effects such as differences in pupil dilation across conditions. Second, the controlled laboratory-like setting, while ensuring consistency, may limit the ecological validity of the findings compared to real match environments. Therefore, future research should address these limitations by including larger samples, considering additional physiological variables (e.g., heart rate, skin conductance), allowing greater tactical flexibility, and incorporating data collected under real match conditions.

Conclusions

The present study examined the influence of the expertise level and task conditions on visual attention and pupil dynamics during penalty kicks. The findings demonstrated that fixation duration, the fixation count, and pupil size were modulated by contextual factors such as goalkeeper presence and shooting direction, and that pupil responses were not differentiated by the player's expertise. Notably, unsuccessful kicks were generally associated with greater pupil dilation, suggesting greater cognitive and attentional demands during unsuccessful performance. Elite players tended to exhibit longer and more stable fixations compared to amateurs, highlighting their superior ability to regulate visual attention and filter task-relevant cues. However, differences in fixation counts towards successful and unsuccessful attempts indicate that the cognitive and perceptual demands of penalty taking may vary not only by the skill level but also by situational constraints. Taken together, the results provide further evidence that penalty performance is strongly influenced by the interaction between perceptual-cognitive processes and contextual demands. While expertise affords advantages in attentional control, all players appear susceptible to stress induced by goalkeeper presence, which can compromise visual efficiency and decision-making.

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