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**Original Article**

# Specialized perceptual-cognitive skills in soccer goalkeepers

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**Abstract**:
**Problem statement**: Soccer goalkeepers face severe time constraints when attempting to defend against shots, particularly during penalty situations. Although previous research has highlighted the importance of anticipatory strategies, it remains unclear whether goalkeepers' perceptual-cognitive expertise arises from soccer-specific adaptations or from more general visuomotor abilities. **Approach**: Thirty participants were divided into three groups: goalkeepers (n = 10), field players (n = 10), and non-athlete controls (n = 10). All tasks were displayed on a PC monitor, and participants responded using the designated keyboard inputs. Three tasks were performed: (a) a soccer-specific prediction task in which videos from a first-person goalkeeper perspective were occluded just before ball contact, and participants predicted shot direction; (b) a soccer-specific reaction task using full-shooting videos from the same perspective, requiring rapid responses to shot direction; and (c) a general visuomotor choice-reaction task in which participants quickly responded to the direction of an arrow stimulus. **Purpose**: This study aimed to clarify whether goalkeepers' perceptual-cognitive advantages are specific to soccer contexts or extend to general cognitive-motor domains and to compare the expertise effects of goalkeepers, field players, and non-athletes. **Results**: Goalkeepers and field players achieved significantly higher prediction accuracy than non-soccer players ($p < .05$, $p < .01$), with no significant difference between soccer player groups. In the reaction task, goalkeepers responded significantly faster than non-soccer players ($p < .05$), whereas field players did not differ significantly from either group. No group differences were observed in the arrow-detection control task. **Conclusions**: Soccer experience enhanced prediction accuracy irrespective of playing position, while goalkeepers uniquely demonstrated faster reactive responses under sport-specific time constraints. No differences were observed in the general tasks, suggesting that these abilities were domain-specific. These findings highlight the specialized perceptual-cognitive skills of goalkeepers and provide implications for soccer training strategies.
**Key Words**: **soccer goalkeeper, perceptual-cognitive expertise, anticipation, reaction time, athlete**

## Introduction

In sports that require athletes to make rapid perceptual decisions under time pressure, such as soccer goalkeeping, fast and accurate reactions to opponents' actions and ball movements are essential. Previous studies have suggested that well-trained athletes often rely on anticipatory strategies rather than purely reactive responses to optimize their defensive performance under severe temporal constraints. Studies have demonstrated that skilled athletes utilize early kinematic cues, such as posture, motion onset, and limb orientation, to predict the outcome of an opponent's action before visual information about ball movements becomes available (Abernethy, 1990; Farrow & Abernethy, 2003; Gray, 2002; Hosp et al., 2021a). These findings suggest that anticipatory skills may be shaped by experience and become highly specialized for specific task contexts such as those encountered in goalkeeping.

Goalkeepers face some of the most demanding time constraints in soccer, especially during penalty kicks. With ball velocities typically ranging from 25 to 30 m/s, a standard 11-meter penalty kick allows less than 450 ms from ball contact until the ball reaches the goal line, with barely enough time for visual processing and motor execution. Consequently, goalkeepers often initiate movement before ball contact (Savelsbergh et al., 2002), underscoring the importance of anticipatory strategies in such scenarios. On the other hand, Peiyong and Inomata (2012) indicated that when a goalkeeper initiated their response before ball contact, their prediction accuracy (i.e., the anticipated direction of the ball) remained at chance level, whereas delayed responses after ball contact significantly improved accuracy, suggesting limited benefits of anticipatory strategies in penalty kick situations. Meanwhile, field players initiated movements later than goalkeepers, suggesting that goalkeepers and field players use different strategies in reaction to a shoot. However, their study was limited to fixed-distance penalty kicks (11 m) and did not separate the anticipatory and reactive components into distinct task conditions. In addition, their study compared only goalkeepers and field players and did not include non-soccer players or novices as controls. As such, it remains unclear whether the observed expertise effects reflect soccer-specific perceptual-cognitive adaptations irrespective of soccer position or broader differences in general athletic populations.


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Moreover, it remains unclear whether goalkeepers' superior performance stems from soccer-specific perceptual expertise or general enhancement in visuomotor processing. Some evidence suggests that athletes, including goalkeepers, may exhibit faster reaction times than non-athletes in non-sports-specific situations (i.e., general experimental tasks) (Cano et al., 2024; Heirani et al., 2012; Yau Meng et al., 2018). However, other studies have found no consistent differences in basic visual ability or choice reaction time between elite athletes and novices or lower-level athletes (Tomczyk et al., 2018). These findings emphasize the need to distinguish between domain-general and domain-specific perceptual-cognitive expertise. To address this issue, the present study incorporated a domain-general visuomotor control task along with soccer-specific prediction and reaction tasks. This design enables the evaluation of whether goalkeepers' perceptual-cognitive advantages are limited to soccer contexts or extended to general visuomotor processing. While perceptual-cognitive expertise is shaped by task-specific experience and deliberate practice (Williams & Ericsson, 2005), the effectiveness of such skills in high-pressure sports situations critically depends on the individual's action capabilities and the tight coupling between perception and movement (Dicks et al., 2010).

In the present study, video stimuli were recorded from a first-person goalkeeper perspective at a distance of 12 meters—1 meter from the standard penalty kick spot. This design decision was made to serve two complementary purposes: first, to provide slightly more time for reactive processing and second, to better reflect typical shot distances encountered during open play. In penalty kick situations, goalkeepers rely heavily on anticipatory strategies and often commit to a dive direction before ball contact, owing to extreme temporal constraints (Savelsbergh et al., 2002). Despite this anticipatory behavior, the success rate of goalkeepers in saving penalty kicks remains low, with savings rates of approximately 20-30% (Hughes & Wells, 2002). This suggests that prediction alone may be insufficient to overcome the temporal limitations imposed by the standard 11-meter distance. By slightly extending the shooting distance to 12 meters, the flight time of the ball increases by approximately 30–50 milliseconds, which is a potentially meaningful buffer that may allow reactive processes to be incorporated into the goalkeeper's response strategy. Supporting the ecological validity of this modification, large-scale analyses of elite match data indicated that a substantial proportion of shots during open play were taken from the 10–20 meter range (Cavus & Biecek, 2022). Therefore, the chosen distance not only alleviates the extreme time pressure typical of penalties but also more realistically approximates common in-game shooting scenarios.

Building on these considerations, this study aimed to clarify how goalkeepers' perceptual-cognitive expertise manifests when both anticipatory and reactive mechanisms are engaged. Specifically, we sought to (1) separately evaluate prediction and reaction performance; (2) compare goalkeepers, field players, and non-soccer players; and (3) examine the specificity of these skills by including a non-sport control task.

Based on prior research, we proposed the following hypotheses:

1. Goalkeepers and field players were expected to outperform non-soccer players on the soccer-specific prediction task, reflecting the perceptual expertise acquired through soccer experience.
2. Goalkeepers were expected to exhibit faster reaction times than non-soccer players, and potentially field players, in the soccer-specific reaction task, reflecting enhanced visuomotor coordination due to position-specific training.
3. No group differences were expected in the non-sports arrow detection task, indicating that any observed advantages are likely specific to soccer-related contexts rather than reflecting general improvements in cognitive motor speed.

By testing these hypotheses, this study aimed to contribute to a more nuanced understanding of the domain-specific and domain-general components of cognitive expertise in soccer goalkeeping.

## Material & methods

### *Participants*

Thirty participants were recruited and assigned to three groups: goalkeepers (GK; n = 10), field players (FP; n = 10), and non-athlete controls (CON; n = 10). A priori power analysis was not conducted because the sample size was comparable to those of previous studies examining perceptual-cognitive performance in athletes (Peiyong & Inomata, 2012; Savelsbergh et al., 2002). Additionally, the number of participants was limited by the availability of goalkeepers in the recruited collegiate soccer team, which had a maximum of 10 active members in that position. The mean ages of the groups were: GK = 19.6 ± 1.8 years; FP = 21.3 ± 1.3 years; CON = 21.7 ± 0.5 years. Soccer experience averaged 12.2 ± 2.3 years for the GK group and 14.2 ± 2.6 years for the FP group. All soccer players (GK and FP) were active collegiate athletes. The GK group had regular match experience as a goalkeeper. The CON group included individuals with no formal soccer experience. Some participants in the CON group were active in other sports such as baseball or track and field. All the participants had normal or corrected-to-normal vision and provided informed consent in accordance with the ethical guidelines of the institution. The study protocol was approved by the Ethics Committee of Jobu University.

### *Stimuli and tasks*

The video stimuli were recorded using an iPhone 14 mounted on a tripod approximately 1.5 meters above the center of the goal line, simulating a first-person goalkeeper's perspective. Soccer balls were placed 12 meters

from the goal line (slightly farther than a penalty mark) to balance anticipatory and reactive demands. Ten collegiate soccer players each executed ten shots (left or right), yielding 100 video clips. Each shot was recorded at 30 frames per second. The video resolution was 1280 × 720 pixels at 30 frames per second (fps). The videos were edited into three types of stimuli using PsychoPy (an open-source software package for psychology experiments) (Peirce et al., 2019) (Figure 1):

1. Prediction task (occluded video): The video was stopped one frame before ball contact to assess the prediction based on kinematic cues. Participants viewed videos occluded just before ball contact and predicted the direction of the ball by pressing "Q" (left) or "P" (right). They were instructed to prioritize accuracy over response speed.
2. Reaction task (full video): The entire shot sequence from approach to net contact was shown. Participants observed full shooting videos from a first-person goalkeeper perspective. Once the direction was judged, participants pressed "Q" (left) or "P" (right) as quickly and accurately as possible.
3. Control task (arrow images): This was a simple choice reaction task in which a left- or right-pointing arrow appeared at random intervals. Participants responded as quickly and accurately as possible to the direction of an arrow appearing randomly on the screen, also using the "Q" or "P" keys.

All tasks were programmed and conducted using PsychoPy (v2024.1.5) on a Windows laptop computer (Precision 3570, DELL). The participants viewed the stimuli on a laptop's internal monitor (15-inch) and responded via a built-in keyboard. Each participant completed 100 trials of the Reaction and Prediction tasks, which were divided into five sets of 20 trials each. For the Control task, participants completed 50 trials in one continuous set. The task order (Reaction, Prediction, Control) was randomized across participants. The participants were allowed to rest between the sets. Before the main tasks, the participants completed five practice trials for each task under identical conditions.

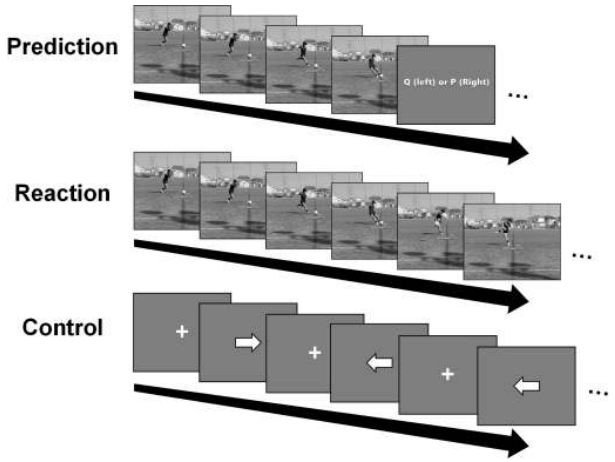


**Figure 1**. Examples of the test stimuli. In the Prediction task, the video was occluded just before ball contact. Participants anticipated the ball's direction. In the Reaction task, the full video was shown until the ball crossed the goal line, and participants responded as quickly and accurately as possible after judging the direction. In the Control task, a left- or right-pointing arrow appeared after a fixation cross, and participants responded accordingly.

***Data Analysis***

The primary outcome measures were reaction time (ms) for the Reaction and Control tasks, and prediction accuracy (%) for the Prediction task. These parameters were automatically calculated using the PsychoPy software. Participants whose accuracy in the Reaction task was below 80% were excluded from further analysis, because the instructions required responding only after judging the ball's direction to minimize anticipatory influences. Practice trials were excluded from all the analyses.

***Statistical analyses***

First, the normality of each parameter within each group was assessed using the Shapiro–Wilk test. The homogeneity of variances across groups was assessed using Levene's test. If both assumptions were satisfied, a one-way analysis of variance (ANOVA) was performed, followed by post-hoc pairwise t-tests with Holm correction. If either assumption was violated, a Kruskal-Wallis test was performed, followed by post-hoc Wilcoxon rank-sum tests (Mann-Whitney U tests) with Holm's correction, if necessary. Statistical significance was set at $p < .05$.

**Results**

***Prediction task***

Normality was confirmed for all groups using the Shapiro-Wilk test, and homogeneity of variances was confirmed using Levene's test. A one-way ANOVA revealed a significant main effect of group on prediction accuracy ($F (2, 27) = 5.942$, $p = .007$). Post hoc t-tests with Holm correction showed that both the GK

and FP groups performed significantly better than the CON group ($p < .05$ and $p < .01$, respectively). No significant differences were observed between GK and FP groups. Additionally, one-sample t-tests showed that the prediction accuracy for all groups was significantly above the chance level of 50% (GK: $p < .001$; FP: $p < .001$; CON: $p < .001$), indicating that the participants' responses were not random (Figure 2A).

***Reaction task***

Three participants with accuracy rates below 80% in the Reaction task were excluded from the analysis of this task (one GK and two CONs), resulting in a final group size of GK: n = 9, FP: n = 10, and CON: n = 8. The remaining 27 participants demonstrated high accuracy (GK: 98.1 ± 2.7%, FP: 98.5 ± 1.3%, CON: 99.3 ± 1.2%), indicating that these participants responded only after judging the ball's direction, thereby minimizing anticipatory bias. As for the reaction time, normality was confirmed for the GK and CON groups but not for the FP group ($p < .05$). The homogeneity of variances was confirmed using Levene's test. Therefore, the Kruskal-Wallis test revealed a significant group effect ($p < .01$). Subsequent pairwise Wilcoxon rank-sum tests with Holm correction showed that the GK group responded significantly faster than the CON group ($p < .05$). No significant differences were observed between the GK and FP groups or between the FP and CON groups (Figure 2B).

***Control task***

Normality and homogeneity of variance were confirmed in all groups. A one-way ANOVA showed no significant group differences in reaction time for the arrow detection task ($F(2, 27) = 0.194$, $p = .825$) (Figure 2C).

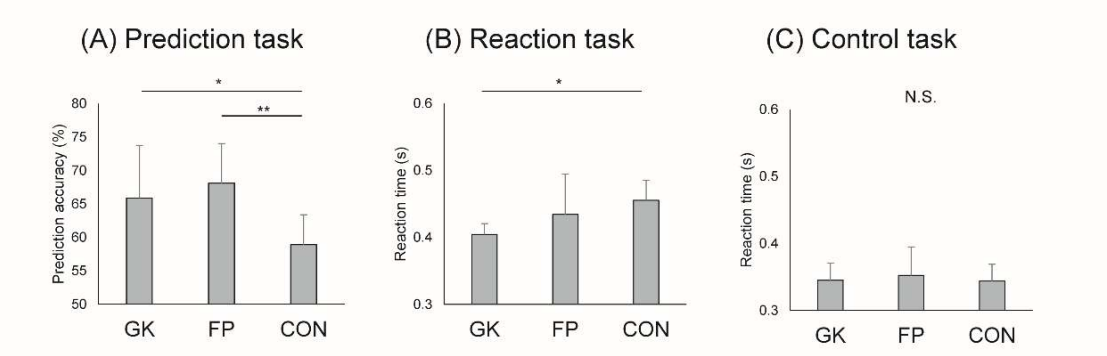


**Figure 2**. Group-level data across the three tasks. (A) In the Prediction task, accuracy was significantly higher in the goalkeeper (GK) and field player (FP) groups compared to the control (CON) group. (B) In the Reaction task, the GK group showed significantly faster reaction times than the CON group. (C) No significant group differences were observed in the Control task. Asterisks denote significant differences (**$p < .01$; *$p < .05$). Error bars represent standard deviation.

**Discussion**

This study aimed to clarify whether goalkeepers' expertise is limited to soccer or whether it reflects broader visuomotor advantages. The results showed that both goalkeepers and field players demonstrated significantly higher prediction accuracy than non-soccer players, whereas only goalkeepers responded significantly faster in the reaction task. No group differences were observed in the general choice reaction tasks. These findings extend the previous research on position-specific perceptual-cognitive skills in soccer by directly comparing goalkeepers, field players, and non-athletes in both sports-specific and domain-general tasks.

In the Prediction task, the superior performance of goalkeepers and field players relative to non-soccer players indicates that soccer experience, regardless of position, facilitates the development of accurate prediction skills. This finding is consistent with previous findings that skilled goalkeepers exhibit more accurate predictions than novice participants (Savelsbergh et al., 2002). Furthermore, our results are consistent with those of a previous study that found no difference in prediction accuracy between goalkeepers and field players (Peiyong & Inomata, 2012). Meanwhile, although Peiyong and Inomata (2012) showed that even goalkeepers performed at chance level when relying solely on pre-contact information, our study showed that all three groups, including non-soccer players, predicted the ball's direction at rates significantly above chance. This may be due to the limited response options, with only two possible directions (left or right). These results, particularly the superior prediction performance of GKs compared to CONs, may reflect the effective use of kinematic cues from the kicker before ball contact, as demonstrated by Savelsbergh et al. (2002). However, because goalkeepers have been shown to initiate their movements in PK situations earlier than field players (Peiyong & Inomata, 2012), their gaze behaviors might differ. As this study did not include eye-tracking measures, the basis for goalkeepers' directional judgments remains unclear, which is a limitation of the current design. In addition, given the binary nature of the task, above-chance performance could, in part, result from probabilistic guessing and thus should be interpreted cautiously.

In the Reaction task, goalkeepers showed significantly faster reaction times than non-soccer players, whereas no significant differences were found between field players and non-soccer players or between goalkeepers and field players. Although the absence of a significant difference between goalkeepers and field players prevents definitive conclusions, the overall pattern suggests that goalkeepers possess superior reactive capabilities. Given that no differences were found in the Control task, which was not a soccer-specific context, it is unlikely that the goalkeepers' faster responses were due to general cognitive-motor speed advantages. Rather, their expertise appeared to manifest specifically under soccer-related time constraints.

In addition to behavioral expertise, extensive sports-specific experience has been shown to induce neuroplastic changes. Well-trained athletes, including soccer players, have been shown to exhibit structural and functional adaptations in the brain regions related to perceptual-motor processing (Di et al., 2012; Fang et al., 2025; Ju et al., 2023; Li et al., 2024; Yan et al., 2025). It is conceivable that goalkeepers' specialized perceptual-cognitive skills observed in this study reflect the long-term neuroplastic changes resulting from the intensive perceptual-motor demands of their positional roles. This possibility underscores the importance of considering both behavioral and neurophysiological factors in understanding the development of expertise in sports.

The current study has several limitations. First, the sample size was relatively small, partly because of the limited number of goalkeepers available in the recruited soccer teams, which may have limited statistical power. Second, the present study focused solely on left-right directional prediction; future research should examine a broader range of contextual cues (e.g., shot height and ball spin). Third, shot direction was not counterbalanced across trials, which may have influenced the participants' prediction performance. In addition, although efforts were made to minimize confounding factors, potential fatigue or learning effects across tasks cannot be entirely excluded.

Beyond these methodological considerations, integrating neurophysiological (Morrone & Pedlar, 2024; Schmaderer et al., 2023; Wang et al., 2019) and eye tracking methods (Hosp et al., 2021a; Hosp et al., 2021b; Piechota et al., 2025) in future studies would contribute to a more comprehensive understanding of the neural and behavioral mechanisms underlying goalkeeping expertise. Furthermore, extending the present paradigm to other sports that require rapid visuomotor responses, such as ice hockey or handball, could help determine whether similar domain-specific advantages are observed.

**Conclusions**

This study suggests that soccer goalkeepers develop specialized perceptual-cognitive abilities that support more accurate predictions and faster reactive responses under sports-specific temporal constraints. These abilities appear to be domain-specific, rather than reflecting generalized cognitive-motor advantages. Further research on the neuroplastic underpinnings of such expertise could offer valuable insights into both theoretical models of skill acquisition and practical training approaches in elite sports.

**Conflicting interest**: The author declares no conflict of interest.

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