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Early identification of the opposition shot taker characterises elite goalkeepers' ability to read the game

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ABSTRACT

Researchers investigating expertise in soccer goalkeepers have overwhelmingly focused on anticipating penalty kicks and identifying kinematic cues that are used to anticipate action outcomes. In this study, we took a novel approach to exploring 'game reading' skills in soccer goalkeepers. Specifically, we investigated whether and by what point during an attacking sequence in open play, elite goalkeepers can identify the opposition shot taker, a skill that is likely to facilitate organisation of the defensive line and interception of forward creative attacking passes. We used a moving window temporal occlusion paradigm to present elite, sub-elite, and amateur goalkeepers with 11-vs-11 attacking sequences that were divided into progressive segments. After viewing each segment, participants identified the player they thought would shoot at goal at the end of the attacking sequence. Elite goalkeepers identified the opposition shot taker earlier and more accurately than sub-elite and amateur participants. Findings suggest that elite goalkeeping is underpinned not only by anticipation of action outcomes but also game-reading skill that enables identification of the player most likely to carry out those actions.

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KEYWORDS
Anticipation; perceptual-cognitive skills; goalkeepers; soccer; game-reading

Anticipation, or the ability to predict future events before they occur, is vitally important in fast ball sports like soccer (Williams et al. 2023). Researchers have shown that expert soccer players can anticipate future actions of opposition players, e.g., whether the opponent will pass or dribble (Gredin et al. 2018), or where attacking passes will be directed (Roca et al. 2011), and that expert goalkeepers can anticipate the area of the goal that a shot will be directed towards (Causer et al. 2017). Although anticipation in soccer has been studied in goalkeepers and outfield players, research which has focused on goalkeepers has almost exclusively been concerned with 'set-play' situations and has typically investigated factors affecting their ability to pick up and utilise kinematic cues, and save penalty kicks (e.g., Williams and Burwitz 1993; Dicks et al. 2010; Causer and Williams 2015). In contrast, anticipation in outfield players has focused more on their 'game reading' in open play environments, i.e., the pick-up of patterns from developing sequences of play, and utilisation of contextual information to assign probabilities to specific event outcomes (Roca et al. 2011, 2013; van Maarseveen et al. 2018). However, the speed with which the ball is moved between players in elite soccer (Wallace and Norton 2014) combined with tactical developments, in which defenders and defensive units typically play in more advanced positions than they had in previous years, means that 'game reading' in open play is becoming increasingly important in the profile of modern-day elite goalkeepers (Otte et al. 2023). Our aim in this study, therefore, was to investigate 'game reading' of goalkeepers in open play by examining whether differences would be present between elite, sub-elite, and amateur soccer goalkeepers in identifying the ultimate shot taker from evolving sequences of play, and if so, at what time point such differences would emerge.

Through extended practice, elite athletes are proposed to develop domain-specific perceptual-cognitive skills that underpin their ability to produce effective motor responses under time constraint (Ericsson et al. 1993; Williams et al. 2011; Kalén et al. 2021). While multiple perceptual-cognitive skills (Williams 2009) such as pattern recognition (North et al. 2011) and probability assignment (Ward and Williams 2003) contribute to expert performance, the overwhelming focus of research has been on the pick-up of emerging kinematic cues (Williams and Jackson 2019). Compared with less-skilled performers, experts have been shown to attend to and extract earlier occurring kinematic cues emanating from the opponent's body movements to judge their intentions (Jones and Miles 1978; Ward et al. 2002; Smeeton and Williams 2012). For example, elite goalkeepers have been shown to pick up key kinematic cues from the hips, kicking leg, and non-kicking leg to judge the outcome of penalty kicks (Savelsbergh et al. 2002; Woolley et al. 2015; Causer et al. 2017).

Identifying the kinematic cues that elite goalkeepers use to anticipate is important for player development (Williams et al. 2002; Abernethy et al. 2012, 2018). Yet, in addition to saving shots at goal, effective goalkeeping involves defending the space in front of the goal to deter oncoming attacks (Lamas et al. 2018; Otte et al. 2020, 2023), for example by intercepting crosses or

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through-balls. Better performing teams have been demonstrated to employ a higher defensive line (Castellano and Casamichana 2015; Forcher et al. 2022), which inherently requires the goalkeeper to adopt the role of a 'sweeper-keeper' and necessitates an ability to read the developing sequence of play. Moreover, in open play, if a goalkeeper is not well positioned to respond to a shot at goal, they are unlikely to make the save regardless of whether they judge the outcome effectively or not (Lamas et al. 2018). Rather than through perception of kinematic cues, which only become available late in an action sequence (Roca et al. 2013; North et al. 2016), effective defence of the space in front of the goal and positioning for upcoming shots are likely to require early identification of the opposition shot taker; a skill more reliant on recognition of emerging patterns of play and probability assignment.

Compared with lesser-skilled counterparts, skilled soccer defenders have been shown to demonstrate a superior ability to recall and recognise structured patterns of play, the suggestion being that perceiving developing sequences facilitates anticipation of the evolving pattern of play (North et al. 2009, 2016). Experts also more effectively pick up and utilise contextual sources of information such as event sequencing, action tendencies, or game score, to assign probabilities to likely event outcomes (Murphy et al. 2018; Runswick et al. 2018; Thomas et al. 2022). For example, when viewing video simulations of 11-vs-11 attacking sequences that occluded immediately before a key attacking pass, Ward and Williams (2003) asked elite and sub-elite youth soccer players to identify the players in the best positions to receive the ball, and to then rank these players according to who they believed would receive the ball (from most to least likely). Compared with sub-elite players, elite players assigned probabilities that more closely reflected the outcome of the attacking sequence. In this instance, contextual information such as the relative movement and positioning of players, and the sequence of passes performed in the lead-up to the key attacking pass, are likely to have contributed to more accurate probability assignment, with elite players more able to process this information to identify the tactical intentions of the opposition team (McRobert et al. 2011; Roca et al. 2011; Murphy et al. 2016).

Despite the majority of goal-scoring opportunities in soccer coming from open play (Wright et al. 2011; Wang and Qin 2020), most research on goalkeeping anticipation has focused on penalty kicks and identification of key kinematic cues (e.g., Williams and Burwitz 1993; Dicks et al. 2010; Causer and Williams 2015). For example, Causer et al. (2017) combined spatial and temporal occlusion methods to identify the extent to which skilled goalkeepers use kinematic cues picked up from the striker's hips to anticipate shot direction and height. In contrast, researchers examining anticipation in outfield players have presented participants with video simulations of 11-vs-11 scenarios, occluded immediately prior to a critical event, and demonstrated the contribution of multiple perceptual-cognitive skills, but they have done so with a focus on judging the final action of the player in possession (Roca et al. 2013; Ward et al. 2013; North et al. 2016). During attacking sequences, goalkeepers would likely benefit from early identification of the opposition player who will ultimately shoot at goal, the assumption being that this will facilitate advance organisation of the defensive line and/or interception of critical attacking passes. Therefore, in this study, we investigated whether, and by what point, elite goalkeepers can identify the opposition shot taker in an evolving sequence of play.

We employed a moving window temporal occlusion paradigm (Farrow et al. 2005) to assess elite, sub-elite, and amateur soccer goalkeepers' ability to identify the opposition shot taker over the course of a developing attacking sequence. Attacking sequences were presented as four sequential two-second segments, with each segment culminating in a freeze frame. During each freeze frame, participants were tasked with identifying the opposition player who would ultimately shoot at goal at the end of the attacking sequence. Based on previous research highlighting skilled soccer players' enhanced perceptual-cognitive skills (e.g., pattern recognition, probability assignment, and kinematic cue usage, North et al. 2011; Roca et al. 2013), we hypothesised that more skilled participants would be able to identify the opposition shot taker at levels significantly greater than chance, and more accurately than less-skilled participants, earlier in the attacking sequence. We also hypothesised that once expertise effects emerged, they would be observed across all subsequent segments of the attacking sequence. Given the exploratory nature of the work, we did not make specific predictions about the time points at which these effects would begin to emerge.

Materials and methods

Participants

A power calculation was conducted using G*Power (version 3.1, Faul et al. 2007). For our 3 (Expertise) × 5 (Temporal Occlusion) interaction, the analysis revealed that 27 participants would be sufficient to detect a medium effect size ($f = 0.25$) with a power of 0.80. Altogether, 30 (10 elite, 10 sub-elite, and 10 amateur) soccer goalkeepers took part. Participant information is presented in Table 1. Of the ten elite participants, three had played as goalkeepers in the English Premier League and two had played internationally (represented their nation in a fixture against another nation). Ethical approval was provided by the university at which the research was conducted, and all participants provided written informed consent.

Table 1. Mean (*SD*) participant characteristics.

	Age (years)	Experience (years)	Training per week (hours)	Current Competitive Level
Elite	28.20 (4.73)	17.30 (3.16)	8.40 (0.70)	Top four divisions of English Football League
Sub-Elite	23.20 (1.62)	13.00 (1.41)	5.20 (1.48)	Top five divisions of National League System
Amateur	24.40 (5.82)	11.70 (4.03)	2.40 (1.74)	Below top five divisions of National League System

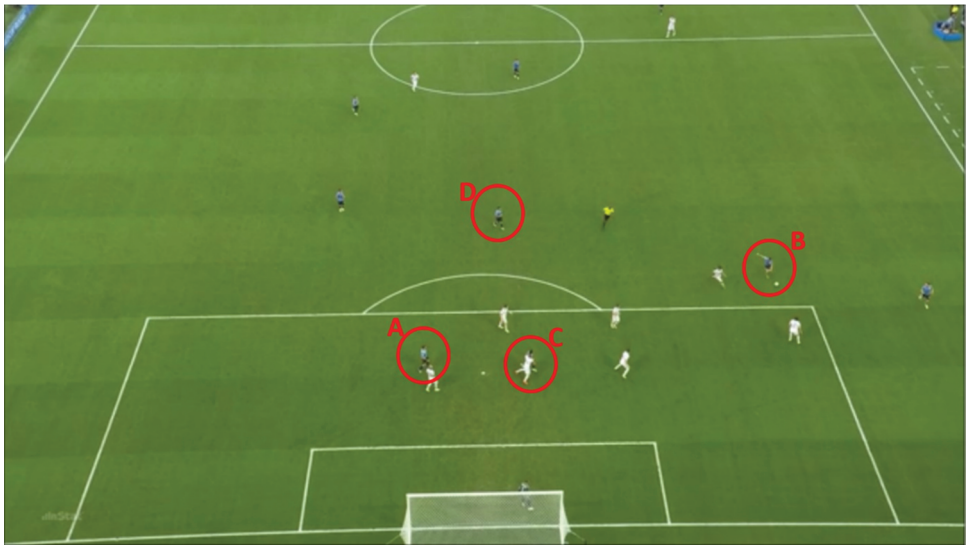

Figure 1. An example freeze frame presenting response options (A, B, C, D).

Test stimuli

Test stimuli were generated from footage of competitive soccer matches at the 2018 FIFA World Cup, downloaded from the platform *InStat Scout*. The footage provided a bird's-eye viewing perspective from behind the goalposts (see Figure 1). A member of the research team, who has 17 years' playing experience as a semi-professional goalkeeper, selected attacking sequences deemed to represent the types of scenarios goalkeepers face in competition. Subsequently, a UEFA A licenced soccer coach verified that all selected attacking sequences were representative of competitive scenarios. All attacking sequences represented a continued build-up of possession by the attacking team (i.e., there were no turnovers of possession within the clips) that culminated in a shot at goal. All trials commenced with the team in possession in the opposition half and progressed with them transferring the ball towards the opponent's goal via a combination of passing and dribbling. All shots were ultimately made with the foot (i.e., no sequences that culminated in headed attempts were used). Half of the shots were attempted from outside the box with the other half attempted from within the box. Trials were selected in this way to ensure that the presented scenarios were representative of competition and to reduce the likelihood that participants would base their response on who is more likely to take the shot based on their usual playing position. Altogether, 18 attacking sequences from five matches involving nine different teams were selected for further editing. To avoid presenting matches that had previously been viewed by participants, matches played by the English national team were not included. Additionally, participants were not informed of what competition the matches were from, and the team names and scorelines were removed (Murphy et al. 2020). Video clips of attacking sequences were initially edited to be eight seconds in length, finishing immediately prior to a shot at goal. Trial duration was based on other studies on game reading in football that have presented trials of similar or shorter duration, e.g., Belling et al. (2015); North et al. (2016); Roca et al. (2013).

To create the moving window temporal occlusion paradigm, each clip was firstly edited into four sequential two-second segments such that the developing attacking sequence could be progressively presented to participants. Next, five freeze frames were generated, corresponding to the moments at which the attacking sequence began and finished, and at two second intervals in between. Four player options, including the player who ultimately shot at goal, were overlaid onto these still frames (see Figure 1). Each freeze frame lasted seven seconds meaning each full trial was 43 seconds long.

Materials and set-up

Test stimuli were edited using Windows MovieMaker (Microsoft, Washington, USA), and presented on a 12.3-inch laptop (Microsoft, Washington, USA). Participants sat approximately 50 cm from the screen, such that the image subtended to a viewing angle of approximately 40-degrees.

Procedure

Participants were instructed that their task was to judge which opposition player would take a shot on goal at the end of each attacking sequence of play. Trials began with a still frame to provide context around the positioning of the ball and the players on the pitch, and to ascertain whether the participant goalkeepers could identify the shot taker solely using early, static player positioning information. Following the seven-second response period, the video played, and the attacking sequence progressed for two seconds, at which point another still frame at that moment in the attacking sequence was displayed, and participants were again asked to identify the predicted shot taker (see Figure 2). Each trial was made up of five still frames and four dynamic video phases. An intertrial interval of seven seconds was employed.

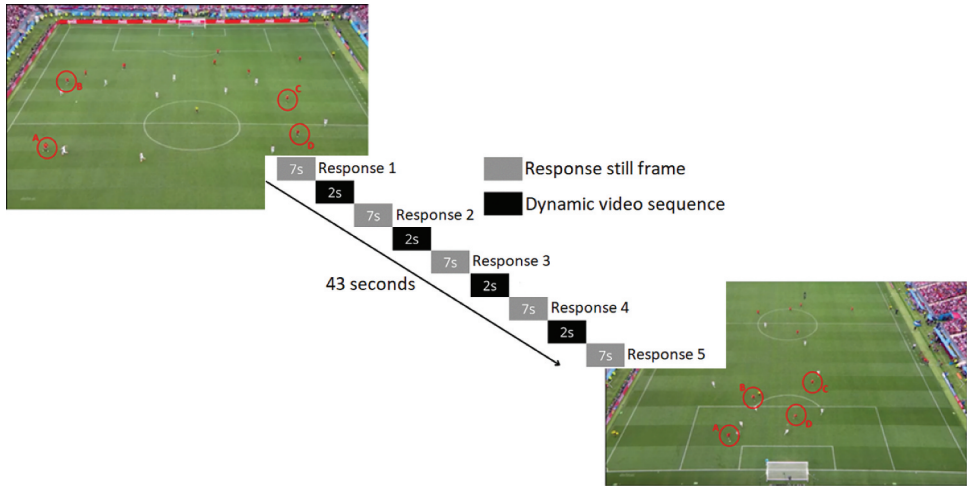

Figure 2. An illustration of the progressive stages of each individual trial with the two still images representing the first and final still frames of an example trial.

During each still frame, participants chose from four response options. Players (response options) were circled and labelled A, B, C, or D with these players and labels remaining consistent throughout the trial (i.e., at each still frame). To respond, participants wrote down the letter that corresponded to the player they judged most likely to shoot at the end of the attacking sequence. Prior to the experimental protocol beginning, participants viewed four familiarisation trials, which were not included in the final experiment. Participants then viewed a total of 18 experimental trials. At no point was feedback provided.

Data analysis

Response accuracy was reported as the percentage of trials on which participants identified the opposition shot taker correctly. First, to determine the time point at which each group could identify the shot taker more effectively than chance, we conducted one-sample t-tests comparing response accuracy of elite, sub-elite, and amateur participants' response accuracy to chance levels (25%) at each time point. Next, to determine differences in the three groups' ability to identify the shot taker across time points, we conducted a 3 (Expertise [elite, sub-elite, amateur]) × 5 (Time Point [1, 2, 3, 4, 5]) mixed ANOVA. Alpha (p) was set at .05. In the case of multiple pairwise comparisons, Bonferroni adjustments were made to account for family-wise error. Effect sizes were calculated using partial eta squared (η_p^2) and Cohen's d values. Partial eta-squared values of 0.01, 0.06, and 0.14, and Cohen's d values of 0.2, 0.5, and 0.8 were considered to reflect small, medium, and large effect sizes (Cohen 1988). 95% confidence intervals are reported on d.

Results

Mean (SE) response accuracy scores are presented in Figure 3. One-sample t-tests revealed that elite participants were able to identify the opposition shot taker more accurately than chance at t2, t3, t4, and t5 (all $p < .05$). In contrast, sub-elite participants were only more accurate than chance at t3, t4, and t5 (all $p < .05$). Amateur participants' responses were more accurate than chance at t4 and t5 (both $p < .05$).

The 3 (Expertise) × 5 (Time Point) mixed ANOVA revealed a significant main effect of Expertise, F (2, 27) = 23.17, $p < .05$, $\eta_p^2 = 0.63$. Elite participants ($M = 53.11$, $SD = 29.14$) were more accurate than both sub-elite ($M = 46.88$, $SD = 26.72$, $d = 1.63$, 95% CI = [0.59, 2.64]) and amateur participants ($M = 38.56$,

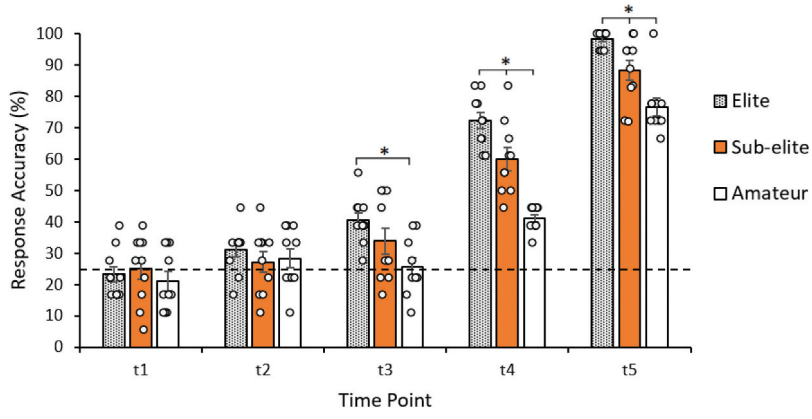

Figure 3. Mean % response accuracy (with SE and individual data points) of elite, sub-elite, and amateur participants across time points. *indicates significant differences between groups ($p < .05$). The dotted line represents chance level.

$SD = 21.98$, $d = 2.93$, 95% CI = [1.62, 4.20]), with sub-elite participants also being more accurate than amateur participants ($d = 1.53$, 95% CI = [0.50, 2.52], all $p < .05$). A significant main effect of Time Point was also observed, F (4, 108) = 282.49, $p < .05$, $\eta_p^2 = 0.91$. Response accuracy increased from t1 ($M = 23.15$, $SD = 9.35$) to t2 ($M = 28.89$, $SD = 9.04$, $d = 0.62$, 95% CI = [0.10, 1.14], $p < .05$). No difference emerged between t2 and t3 ($M = 33.33$, $SD = 11.67$, $d = 0.43$, 95% CI = [−0.09, 0.94]). However, response accuracy increased again from t3 to t4 ($M = 57.78$, $SD = 15.41$, $d = 1.79$, 95% CI = [1.18, 2.38], $p < .05$), and from t4 to t5 ($M = 87.76$, $SD = 11.90$, $d = 2.18$, 95% CI = [1.53, 2.81], $p < .05$). However, these main effects were superseded by a significant Expertise × Time Point interaction, F (8, 108) = 5.30, $p < .05$, $\eta_p^2 = 0.28$. Pairwise comparisons revealed no differences between groups at t1 or t2. However, at t3, elite participants ($M = 40.56$, $SD = 7.43$) identified the shot taker more accurately than amateurs ($M = 25.56$, $SD = 9.15$, $d = 1.80$, 95% CI = [0.73, 2.84], $p < .05$). At t4, response accuracy was higher for elite ($M = 72.22$, $SD = 8.28$) than sub-elite ($M = 60.00$, $SD = 11.65$, $d = 1.21$, 95% CI = [0.24, 2.16]) and amateur participants ($M = 41.11$, $SD = 3.88$, $d = 4.81$, 95% CI = [3.01, 6.58]), while sub-elite participants were also more accurate than amateur participants ($d = 2.18$, 95% CI = [1.03, 3.28], all $p < .05$). At t5, elite participants ($M = 98.33$, $SD = 2.68$) were again more accurate than sub-elite ($M = 88.28$, $SD = 10.35$, $d = 1.33$, 95% CI = [0.34, 2.29]) and amateur participants ($M = 76.67$, $SD = 9.00$, $d = 3.26$, 95% CI = [1.87, 4.62]), with sub-elite participants remaining more accurate than amateur participants ($M = 72.22$, $SD = 8.28$, $d = 1.20$, 95% CI = [0.23, 2.14], all $p < .05$).

Discussion

To date, researchers investigating anticipation in elite goalkeeping have predominantly focused on the penalty kick scenario and the pick-up of kinematic cues (e.g., Williams and Burwitz 1993; Dicks et al. 2010; Causer and Williams 2015). However, the ability to 'read the game' in open play scenarios is underpinned by multiple perceptual-cognitive skills, such as pattern recognition and probability assignment, and is important in the make-up of the modern-day goalkeeper (Lamas et al. 2018; Otte et al. 2023). To our knowledge, this is the first study to investigate elite goalkeepers' ability to read the game in open play scenarios. Specifically, we employed a moving window temporal occlusion paradigm to investigate whether, and by what point in an attacking sequence, elite, sub-elite, and amateur goalkeepers could identify the opposition shot taker from an evolving sequence of attacking play.

In line with our first hypothesis, the time point at which participants were able to identify the opposition shot taker was dependent on skill level. Elite goalkeepers' judgments were more accurate than chance earlier in the action sequence than sub-elite goalkeepers, who were able to accurately identify the opposition shot taker earlier than amateurs (in the current study, six, four, and two seconds prior to the shot being taken, respectively). Each group continued to respond above chance levels for the remainder of the attacking sequence. In summary, the moment at which participants correctly identified the opposition shot taker became progressively earlier with increasing expertise. Particularly noteworthy is how early in the attacking sequence that elite goalkeepers were able to identify the opposition shot taker. Our findings are the first to demonstrate that elite soccer goalkeepers can identify key opposition players well in advance of the critical event, i.e., the shot at goal, a skill that is likely to facilitate effective organisation of the defensive line and interception of key attacking passes.

When comparing participants' ability to identify the opposition shot taker, expertise level differentiated between groups from t3 to t5. No significant differences were observed at t1, suggesting that the static player positioning information available at that point was not sufficient to inform identification of the shot taker, supporting previous conclusions regarding the importance of motion information, and in particular relative motion, to pattern perception and expertise (Williams et al. 2006, 2012). Differences only began to emerge at t3 (4 s prior to the shot being taken at goal), when elite goalkeepers identified the opposition shot taker more accurately than amateurs. At t4 (2 s prior) and t5 (immediately prior), elite goalkeepers were also more accurate than sub-elite goalkeepers, who in turn were more accurate than amateurs. Because relevant kinematic cues from the shot taker would only have become available by t5, we infer that identification of the opposition shot taker at the earlier timepoints would have been underpinned by pattern recognition and the utilisation of contextual information to assign probabilities to potential shot takers. Specifically, by t3, the attacking sequences would have developed to a point that elite goalkeepers could extract key contextual information from the relative movements of the players and sequences of passes being played, to identify the opposition shot taker more accurately than their less-skilled counterparts (Loffing et al. 2015; North et al. 2017; Murphy et al. 2018). Then, at t5, the pick-up of kinematic cues would also have contributed to their judgments to confirm or revise their decision based on the available contextual information (Gredin et al. 2020; Runswick et al. 2020). These findings add to the body of evidence highlighting that expert performance is underpinned by multiple perceptual-cognitive skills that vary in importance depending on the task constraints (Roca et al. 2013; North et al. 2017).

Cumulatively, our findings extend previous research (e.g., Roca et al. 2013; Causer et al. 2017; North et al. 2017) by highlighting that not only do the time constraints of elite soccer require goalkeepers to develop the ability to anticipate *what* the opponent will do (e.g., pass or shoot), but also, *who* will do it. Early identification of the opposition shot taker is likely to facilitate effective positioning in the goal, organisation of the defensive line, and interception of key attacking passes, while anticipation of the action outcome facilitates coordination of the save (Dicks et al. 2010, 2010; Navia et al. 2013). This may be particularly pertinent considering the tendency for modern-day elite defenders to hold a high line (Castellano and Casamichana 2015; Forcher et al. 2022), increasing the requirement for goalkeepers to identify the eventual shot taker in advance, in order to anticipate and intercept forward passes.

Although we have suggested that early identification of the opposition shot taker may facilitate effective positioning for the upcoming shot, organisation of the defensive line, and interception of key passes, our paradigm did not allow us to validate these claims. Rather, ours are the first findings to demonstrate that elite goalkeeping is underpinned by early identification of the opposition shot taker, opening the door for future research into *if* and *how* this contributes to more effective on-field performance. As a starting point, observational research could be conducted to track goalkeeper behaviour throughout attacking sequences to ascertain the extent to which their movements and interactions with defenders are coupled to those of the opposition shot taker (McGarry et al. 2002; Ramos et al. 2017; Caetano et al. 2020). It is possible that identification of the opposition shot taker underpins multiple facets of elite goalkeeping, facilitating organisation of the defensive line early in the attacking sequence to deter the developing attack, and goalkeeper positioning later in the sequence to prepare to save the upcoming shot. The latter seems likely given that should the goalkeeper reposition themselves too early, the opposition team may alter their attack accordingly. Identifying the opposition shot taker early in the attacking sequence may nevertheless facilitate effective planning of future positioning, promoting a pro-active over a reactive approach.

Experimental paradigms in which gaze and verbal report data is collected could be employed to further identify the processes and information sources underpinning early identification of the shot taker (Savelsbergh et al. 2002; Roca et al. 2011; Hosp et al. 2021). Moreover, qualitative methods could elucidate the experience of goalkeepers, to gain a deeper understanding of decision-making in open-play situations (e.g., Levi and Jackson 2018). For example, it is likely that elite goalkeepers base their judgements on information picked up from both the relative movements and sequence of passes played by the opposition team and the condition of their own defensive line (e.g., by identifying gaps through which opponents may attack). This would be interesting to explore across different types of tactical build-up in which the nature and complexity of the contextual information available, and in turn the information used to identify the opposition shot taker, varies. This line of research could facilitate the development of training interventions to enhance this skill (Williams et al. 2011).

The skill differences observed in the current study highlight the need for researchers to broaden their perspective of the facets of anticipation that can be trained, and the skill level of athletes who may benefit from such training. Of particular note is that our test of players' ability to identify the opposition shot taker differentiated between elite and sub-elite athletes, both of whom compete at a very high level, suggesting that training programmes designed to develop this skill may be beneficial across the expertise spectrum. To date, however, researchers have focused most of their attention on identifying methods to develop perception of kinematic cues in inexperienced performers (Broadbent et al. 2014; Williams and Jackson 2019), with only limited attention afforded to other perceptual-cognitive skills such as pattern recognition or recall (Gorman and Farrow 2009; North et al. 2017), or the pick-up of contextual cues to inform probability assignment (Ward and Williams 2003). We therefore suggest that increased efforts should be made to design training protocols to facilitate game reading skills for more holistic talent development. Video-based training interventions involving instruction highlighting key cues, and feedback provision, could be employed to encourage early identification of the opposition shot taker (Williams et al. 2002; Abernethy et al. 2012; Murgia et al. 2014), and may be particularly useful when athletes are injured. Alternatively, field-based training environments would inherently facilitate interaction between the goalkeeper, the defensive line and the opposition team, and the tracking of behaviours associated with identification of the shot taker, such as goalkeeper positioning and interception of key passes. While more representative of competition (Pinder et al. 2011), the frequency with which attacking scenarios can be recreated and reduced levels of control in field-based interventions highlight the potential for virtual reality-based interventions as a feasible alternative (Stone et al. 2018; Faure et al. 2020; van Biemen et al. 2023).

This study is not without limitations. First, the bird's-eye viewing perspective employed was not representative of that normally experienced by goalkeepers (Pinder et al. 2011), and response accuracy levels may have been elevated compared to what would normally be observed in competition (Mann et al. 2009). Also, while the observation of skill-based differences provides construct validity for the approach, it is nevertheless possible that more skilled participants had greater experience viewing footage from this perspective, e.g., when working with performance analysts. Second, given that we presented footage from the 2018 FIFA World Cup, participants may have been familiar with the matches/scenarios presented. Efforts were made to reduce potential familiarity effects and none of the participants verbally commented on being familiar with the matches or scenarios presented. However, to account for the above limitations, future research should aim to present novel stimuli from a first-person viewing perspective. Again, virtual reality paradigms may prove particularly useful in this respect (Bideau et al. 2009; Faure et al. 2020; Wood et al. 2021). A third limitation of the current study is the relatively small sample size. Our study design required highly skilled soccer goalkeepers but, as highlighted by Schweizer and Furley (2016), when conducting research on expertise it is not always feasible to employ large sample sizes given the difficulty in accessing such small populations. Nevertheless, while the effect sizes of many of the observed statistically significant findings were large, confidence intervals for these effect sizes were also large. Therefore, further research is needed to ascertain whether those comparisons that yielded small to medium effect sizes in particular are replicated. It is important to note, however, that the observed large between-group effects represent skill-based differences between elite, sub-elite, and amateur goalkeepers, rather than experts and novices, highlighting the potential practical significance of the findings.

In this study, we have provided novel evidence that elite goalkeepers' ability to read the game is characterised by early identification of the opposition shot taker. When viewing attacking sequences, elite goalkeepers were able to identify the player who would ultimately shoot at goal earlier and more accurately than sub-elite and amateur goalkeepers. The

findings highlight that elite goalkeeping is not only underpinned by anticipation of action outcomes but also identification of the player most likely to carry out those actions. Future research should aim to investigate the relationship between early identification of the opposition shot taker and on-field performance, as well as training methods that could be used to develop this skill.

Disclosure statement

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Availability of data and materials

Datasets and materials used are available from the corresponding author upon request.

Ethics approval and consent to participate

Research ethics committee approval was received from the institutions of the second and last authors and the study conducted in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from all individual participants included in the study.

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