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No evidence that visual exploratory activity distinguishes the super elite from elite football players

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ABSTRACT
Visual exploratory activities (VEA) refer to head and body movements that football players make prior to receiving the ball to search possibilities for action. VEA is considered a key performance indicator that differentiates the skill level of players. This study revisited whether VEA also distinguishes super elite, award winning players from their elite teammates without awards. To this end, video footage from the men's UEFA Champions League season 2018–2019 featuring the super elite players ($n = 18$) and the elite players ($n = 18$) was analyzed. To reduce the potential differences in match dynamics as much as possible, the selected players in the two groups were of the same team, playing the same match, in the same positioning line. VEA (i.e. frequency per unit time) during the penultimate and final pass prior to ball reception and performance (i.e. percentages of adequate ball contacts and subsequent actions) were compared between the two groups of players using ANOVA and Mann-Whitney tests, respectively. In addition, hierarchical stepwise regression analyses were conducted to explore the degree to which VEA was predicted by group and subsequent performance. The results showed that the players had higher VEA during the final pass ($M = 0.45$) than the penultimate pass ($M = 0.41$). There were no significant differences in VEA or performance between the two groups. Also, the regression analyses did not deliver significant models. We conclude that with partial control for match dynamics, no evidence emerged to support that VEA distinguishes super elite players from elite football players.

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Introduction

Elite football players manifest themselves through increased levels of visual exploratory activity (VEA). They show higher rates of VEA prior to receiving the ball than players who are less skillful (Jordet et al. 2013, 2020; McGuckian et al. 2020; Aksum et al. 2021; Pokolm et al. 2022). VEA was defined by Jordet (2005) as 'a body and/or head movement in which the player's face is actively and temporally directed away from the ball, seemingly with the intention of looking for teammates, opponents and other environmental objects or events, relevant to the carrying out of a subsequent action with the ball' (p. 143). VEA grants early perception of the possibilities of actions (i.e., affordances) in the situation and is associated with a more successful outcome of the action immediately following ball reception (Eldridge et al. 2013; Jordet et al. 2013, 2020; McGuckian et al. 2017, 2018, 2020; Phatak and Gruber 2019; Aksum et al. 2021, 2021; Pokolm et al. 2022; Caso et al. 2023). From the perspective of ecological psychology (Gibson 1966, 1979), VEA is an active search for information involving the whole body that results in the attunement to information that specifies the most relevant possibilities for action. Accordingly, perceptual skill in football is considered as a flexible, largely unreflective, situated awareness, rather than the stockpiling of (shared) conscious knowledge. In essence, skill arises from the ongoing, active visual exploration of the environment, enabling players to flexibly adapt to the emerging and dissolving possibilities for action in a match (Fajen et al. 2009).

Jordet et al. (2013) reported that among elite midfielders from 20 English Premier League (EPL) teams, super elite players who had received a prestigious individual award (e.g., the FIFA World Player of the Year, Ballon d'Or) used more frequent VEA than elite players without awards. The super elite were also more effective in their subsequent actions with the ball (i.e., success in passing). Recent work has reinforced these observations for elite youth players. Pokolm et al. (2022) studied players competing in the U17 and U19 European Championship and found that players with more appearances for their national team produced higher rates of VEA. Similarly, Aksum et al. (2021) found that elite U19 players produced more VEA than U17 players (see also McGuckian et al. 2020). Taken together, emerging evidence suggest that VEA is a key performance indicator that can differentiate skill level, including the fine-grained differences between elite and super elite players.

However, other constraints must be considered in understanding the relationship between VEA and skill level. Foremost, VEA is not merely an attribute of the individual player but emerges in the interaction with the environment. For example, the rate of VEA depends on a player's position in

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the team. Players playing on the midfield and/or on the central axis produce higher rates of VEA than players in defense and attack and/or on wide axes (Jordet et al. 2020; Aksum et al. 2021; Pokolm et al. 2022; Caso et al. 2023). The situational dynamics of the match is another critical constraint on VEA. It stands to reason that match dynamics can vary significantly among teams of different age and competition level, especially with respect to the pace of the game (McMorris 2004; McGuckian et al. 2019). In the study by Jordet et al. (2013), comparing VEA in elite and super elite midfielders, the match dynamics may have differed significantly. The super elite awardees mostly played for top 3 teams with highly skilled teammates, while the non-awardees typically played for lower positioned teams. In all likelihood, the super elite players more often encounter high pace games, presumably inviting more frequent and earlier VEA (cf. Jordet et al. 2013; Pokolm et al. 2022), as would have been the case for youth players when they grow older (Aksum et al. 2021). By contrast, VEA has been found to be affected by the opponent team's pressure (Eldridge et al. 2013; Jordet et al. 2020; Aksum et al. 2021, 2021; Pokolm et al. 2022). In this respect, it may be that the teams which are competing to win the league play more often against teams with more defensive tactics and reduced willingness to create high pressure. To increase control for these and other potential confounders related to match dynamics, we compared VEA of super elite and elite players from the same team in the same matches.

The rate of VEA is typically determined over a period of 10 s prior to ball reception (Jordet et al. 2013; McGuckian et al. 2018; Pokolm et al. 2022). Yet, the possibilities for action quickly change during this 10-s period (McGuckian et al. 2020). In this respect, it follows from an ecological psychology perspective that VEA is more strongly related to the progression of passes in the game than to mere time measured in seconds (Caso et al. 2023). Because passes are nested within tactical patterns of play, elite players typically can perceive several passes ahead that they will receive the ball (via intermediate players). Consequently, ongoing visual exploration is more likely to be aligned with this dynamic progression of passes than with time intervals in seconds. For example, players increase VEA because the ball is two passes away and not because there are four seconds remaining before they receive the ball. Accordingly, Caso et al. (2023) compared the rate of VEA in the penultimate and final passes before ball reception. Elite players produced more VEA during the final pass than during the penultimate pass, but, more importantly, the rate of VEA during the penultimate pass predicted success in passing after receiving the ball. VEA during the final pass did not further explain the passing performance. Indeed, there is a wealth of evidence suggesting that skilled athletes pick up relevant information further in advance of performing an action than their less skilled counterparts, also in football (Williams et al. 1994; Savelsbergh et al. 2006). However, it has not been examined whether super elite players also distinguish themselves in the timing of VEA.

Hence, the current study analyzed the rate of VEA of super elite and elite football players to verify the previously observed skill level differences in VEA at the adult elite level (Jordet et al. 2013). The super elite group consisted of players who were selected for the UEFA Champions League Squad of the Season 2018–2019, while their non-selected teammates formed the elite group. To control as much as possible for confounders related to match dynamics, we selected teammates who played in the same match in the same position or in the same line (i.e., defense, midfield, or attack).[1] We examined skill differences in the rate of VEA during the penultimate and final passes, and explored the degree to which VEA predicts the adequacy of a player's subsequent action (i.e., passes, dribbles and shots on goal). We hypothesized that the rate of VEA would be higher for the super elite players compared to the elite players both during the penultimate and the final pass. Further, we expected that the rate of VEA would predict the adequacy of subsequent actions, especially for the penultimate pass and more strongly among the super elite players.

Method

Participants

A total of 36 players were included, 18 super elite players and 18 elite players. The super elite players were selected from the UEFA Champions League Squad of the Season in the 2018–2019 season. The UEFA Champions League Squad of the Season is an annual list of outstanding players who have demonstrated exceptional performances during the tournament. They are selected by UEFA Technical Observers, who are mostly former professional players and/or managers of national teams. Super elite players ranged in age from 19 to 34 years ($M = 26.9$ years, $SD = 4.3$), while the comparison elite group ranged in age from 21 to 33 years ($M = 28.1$ years, $SD = 3.6$). The players of the elite group were chosen to match as much as possible the players of the super elite group. To this end, for each player in the super elite group, a player in the elite group was selected using the following three criteria: the paired player must 1) be a teammate; 2) play in the same match, and 3) play in the same position, and if not available in the same line (i.e., defense, midfield, attack). In previous work, both the line and the axis (i.e., central, wide) have been reported to affect VEA (McGuckian et al. 2017, 2018, 2020; Jordet et al. 2020; Aksum et al. 2021; Pokolm et al. 2022; Caso et al. 2023). Hence, to maximize the similarities between the super elite and elite groups, we preferably selected a teammate who played in the same position, that is, in the same line and in the same axis. However, in five out of 18 pairings this was not possible because, depending on a team's tactical formation (e.g., a central midfielder within a 4-3-3 formation), this meant that the two players would have played in the same position in the team. Because the previously reported effects of line positioning on VEA were more consistent and systematic than the effects of axis (McGuckian et al. 2017, 2018, 2020; Jordet et al. 2020; Aksum et al. 2021; Pokolm et al. 2022; Caso et al. 2023), the remaining five pairs were matched with regard to line only. Both groups consisted of six defenders, six midfielders, and six attackers. Goalkeepers were excluded. Within the super elite group, nine players were playing wide and paired to six wide and three central playing elite players; the other super elite players were playing central and paired to seven central and two wide playing elite players.

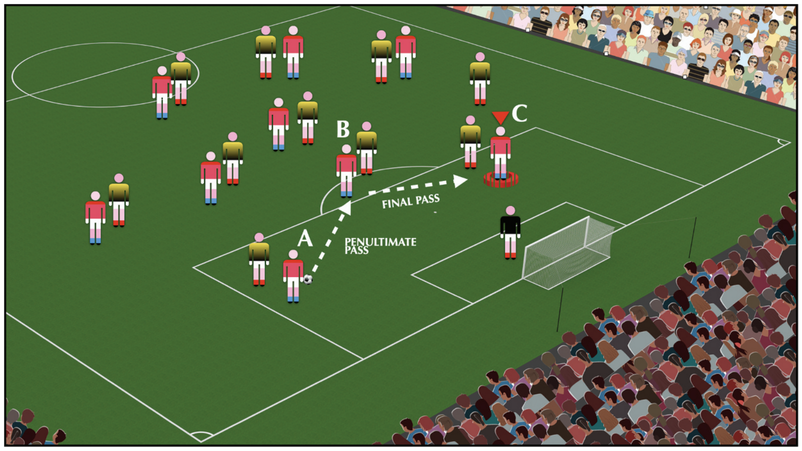

Figure 1. Schematic depiction of the penultimate and the final pass.

For each player, we planned to analyze three full matches (i.e., more matches would have led to a stark reduction of available players). One super elite attacking player did not play any full match and was replaced by an attacker from the UEFA Team of the Year 2019. Of the 18 super elite players, 11 were also on the list of 26 nominated for the FIFA Ballon d'Or 2019. One of the players was the winner of the FIFA Ballon d'Or 2019 and another won the Kopa Throphy. For each player, three matches were analyzed, apart from one super elite player who played only two matches. Therefore, in total, 107 player matches were included for analysis. To further reduce contextual differences between the groups of players, the selection of matches for a player began from the UEFA Champions League final down to group stage matches. For example, if a Liverpool player competed in the final (versus Tottenham), but not in the semifinals (versus Barcelona), then the quarterfinal matches (versus Porto) were analyzed.

Procedure

The video footage was taken from 29 matches. The recordings were obtained through the online platform Wyscout (wyscout.com). The first author is a performance analyst of one of the teams that reached the semifinal stage. Hence, 17 players from 10 matches were analyzed through the club's video archive. For 10 of these players, all matches were from the archive; for three players, two matches were from the archive; and for four players, one match was from the archive. SportsCode Elite software was used for analyses. It allowed, among others, to reduce viewing speed to ¼ of normal speed.

For each participant, we selected as many ball receptions as available according to the following inclusion criteria. To ensure VEA data during both penultimate and final passes, only ball receptions from a series of at least two uninterrupted passes made by teammates were included.

Headers were excluded from the analysis (Caso et al. 2023), because header receptions involve distinct gaze patterns to intercept the ball that may interfere with VEA. Incidental passes resulting from a ball bouncing off a tackle were also excluded, because the series of passes start unintentionally. Also passes from set-piece situations such as free kicks, throw-ins, goal kicks, kick-offs, passes from dropped balls, passes where opponents interfered with the ball, and receptions where the player was fouled and thus unable to perform a subsequent action were all excluded (Caso et al. 2023). Furthermore, the quality of the video footage needed to allow for a reliable identification of the head movements (Jordet et al. 2020). Hence, ball receptions near the far end of the pitch were typically excluded because the colourful audience and advertisement background together with rapidly moving camera shots hampered the identification of head movements. This resulted in the selection of 1,131 ball receptions, with the number of receptions per participant ranging between 8 and 78.

VEA was defined as the receiving player's head turns by which the face was temporally directed away from the ball (Jordet 2005; Jordet et al. 2013, 2020). Unlike Jordet et al. (2013), we did not restrict analysis to situations where the ball was behind the back. Accordingly, each time the head of the player moved away from the ball, one VEA was counted (e.g., if the face of the participant moved away from the ball, turned toward the ball, and then again moved away from the ball, two VEAs were counted, irrespective of where the ball or opponent was). This was done separately for the penultimate pass and the final pass (Figure 1).

Coding for the penultimate pass started the moment at which passing player A received (i.e., contacted) the ball and ended when the ball was received by his teammate, player B. This started coding for the final pass, until the ball was received by the receiving player C. For each pass, its duration (milliseconds) and the number of VEAs made by receiving player C were coded. Next, the action of the receiving player C immediately after ball reception was coded (Caso et al. 2023). We coded ball contacts and subsequent actions such as dribbling, passing, or shooting actions and their adequacy (Table 1).

The notational analysis was performed by the first author (SC), who is also a professional football performance analyst. To determine interobserver reliability, a football performance analyst with three years of experience, who was also a MSc student in human movement sciences, independently analyzed a random sample of 10 players for one entire match (i.e., ≈ 10% of the dataset), totaling 97 receptions. Intraclass correlation coefficient (ICC) with a two-way random effects model for

Table 1. The definition of subsequent actions and their adequacy.

Type of actions	Description
Ball contact	A player received (i.e., touched) the ball. If any action (i.e., pass, shot on goal or dribble) ensued from ball contact, then ball contact was considered adequate, otherwise (e.g., ball jumping from foot to opponent) ball contact was considered as inadequate. A 'one touch' pass was considered as adequate ball contact as well as a pass.
Passing	The ball is kicked in the direction of a teammate or (intentionally) into the (empty) space for a running teammate. If the pass reached the teammate, then it was coded as adequate; if the pass did not reach the teammate, it was coded as an inadequate. Passes that resulted in off-side were coded as inadequate. A 'one touch' pass was considered as an adequate ball contact as well as a pass.
Shooting	The ball is aimed at the goalmouth (i.e., to score a goal). If it ended within the goalmouth, then it was considered adequate, irrespective of whether it entered the goal; otherwise, the shot was coded as inadequate.
Dribbling	The player makes more than two sequential ball touches (see Dellal et al. 2010). It was considered adequate if ball possession was maintained and inadequate if the ball was lost.

consistency for the number of VEA showed excellent reliability for both the penultimate pass (i.e., ICC = 0.91) and the final pass (i.e., ICC = 0.97) (Koo and Li 2016.) Cohen's kappa (k) was used to calculate the reliability for identifying the subsequent action (Cohen's k = 0.96) and its adequacy (k = 0.97). Both were excellent (Koo and Li 2016).

Data analysis and statistics

For each ball reception, the rate of VEA was determined by dividing the number of VEAs by the duration (in milliseconds) of the pass. This was done separately for the penultimate and final passes. Next, each player's average rate of VEA was calculated by averaging the rate of VEA for all receptions for the penultimate and final passes, separately. This was done for each included reception within each match, and thereafter the average of each match was calculated, and finally the average of the three match averages multiplied by 1000 was the rate of VEA in seconds. The percentage of adequate ball contacts (i.e., the total number of adequate ball contacts divided by the total number of ball contacts multiplied by 100) and the percentage of adequate subsequent actions (i.e., the total number of adequate passes, dribbles, and shots divided by the total number of adequate ball contacts multiplied by 100) were determined. We used the same method that was employed to calculate the VEA rates. This involved first computing the percentages per match and then taking the average across the three matches.

Shapiro-Wilk tests indicated that the rate of VEA was normally distributed but the percentage of adequate ball contacts and the percentage of adequate subsequent actions were not. The rate of VEA was submitted to a 2 (group: super elite, elite) by 2 (timing: penultimate, final pass) ANOVA with repeated measured on the last factor. Post hoc tests were conducted using t-tests with Bonferroni correction. Effect sizes are reported using η_p^2 with $\eta_p^2 < .06$, $.06 < \eta_p^2 < .14$, and $\eta_p^2 > .14$ as small, moderate, and large, respectively (Cohen 1969). In addition, the subsequent actions (i.e., percentages of adequate ball contacts and subsequent actions) were compared between the super elite and elite groups using a Mann-Whitney test. The corresponding effect sizes were calculated using the rank-biserial correlation coefficient (r), with $r < .10$, $.10 < r < .30$, and $r > .30$ taken as small, moderate, and large effect sizes, respectively (Rosenthal 1991). To further explore the association of the rate of VEA and group with the percentages of adequate ball contacts and subsequent actions, two separate hierarchical stepwise regression analyses with three steps were conducted. In the first step, the rate of VEA during the penultimate pass was entered to assess the role of early VEA. In the second step, the rate of VEA during the final pass was added to assess whether late VEA augmented any contribution to predicting VEA during the penultimate pass. In the final step, the two interaction terms of the rate of VEA during the penultimate pass and the rate of VEA during the final pass with group were entered. The interaction terms were considered relevant if adding them resulted in a significant improvement in model fit, as evidenced by a significant increase in R^2 (Brocken et al. 2016). For both regressions, outliers that disproportionally influenced the regression parameters (i.e., Cook's D > 1; Cook and Weisberg 1982), the assumptions of homoscedasticity (i.e., by inspecting the standardized residuals by standardized predicted values plot), error-independence (i.e., Durbin-Watson), lack of multicollinearity, and normal distribution of residual errors (e.g., non-significant Kolmogorov-Smirnov) were verified. Because the residual errors did not show an unambiguous normal distribution, wild bootstrapping with 2,000 reiterations was performed (Caso et al. 2023). The associated bootstrap CIs were used to determine the regression coefficients as they make no assumptions about the shape of the distribution (Efron and Tibshirani 1993). Analyses were performed using SPSS 29.0.0.0.

Results

Rate of VEA

The mean VEA rate in the penultimate pass for the elite group was 0.39 (SD = 0.10), while for the super elite group this was 0.42 (SD = 0.11). In the final pass, the mean VEA rate were 0.46 (SD = 0.13) and 0.44 (SD = 0.12) for the elite and super elite group, respectively (Figure 2). Analysis of the VEA rate indicated a significant effect of timing, $F(1,34) = 8.10$, $p = .007$, $\eta_p^2 = .19$, with a higher rate of VEA in the final pass ($M = 0.45$, SD = 0.12) compared to the penultimate pass ($M = 0.41$, SD = 0.10). There was no significant main effect for group, $F(1,34) = .001$, $p = .98$, $\eta_p^2 = .001$, and there was no significant interaction between group and timing, $F(1,34) = 1.67$, $p = .21$, $\eta_p^2 = .047$ (Figure 2).

Performance

Regarding the percentage of ball control, the mean for the elite group was 98.6% (SD = 2.3) and 96.2% (SD = 11.8) for the super elite group (Figure 3). Therefore, no significant effect for group was found, $U(36) = 133$, $z = -1.01$, $p = .37$, $r = -.12$. Also, the percentage of adequate subsequent actions did not reveal

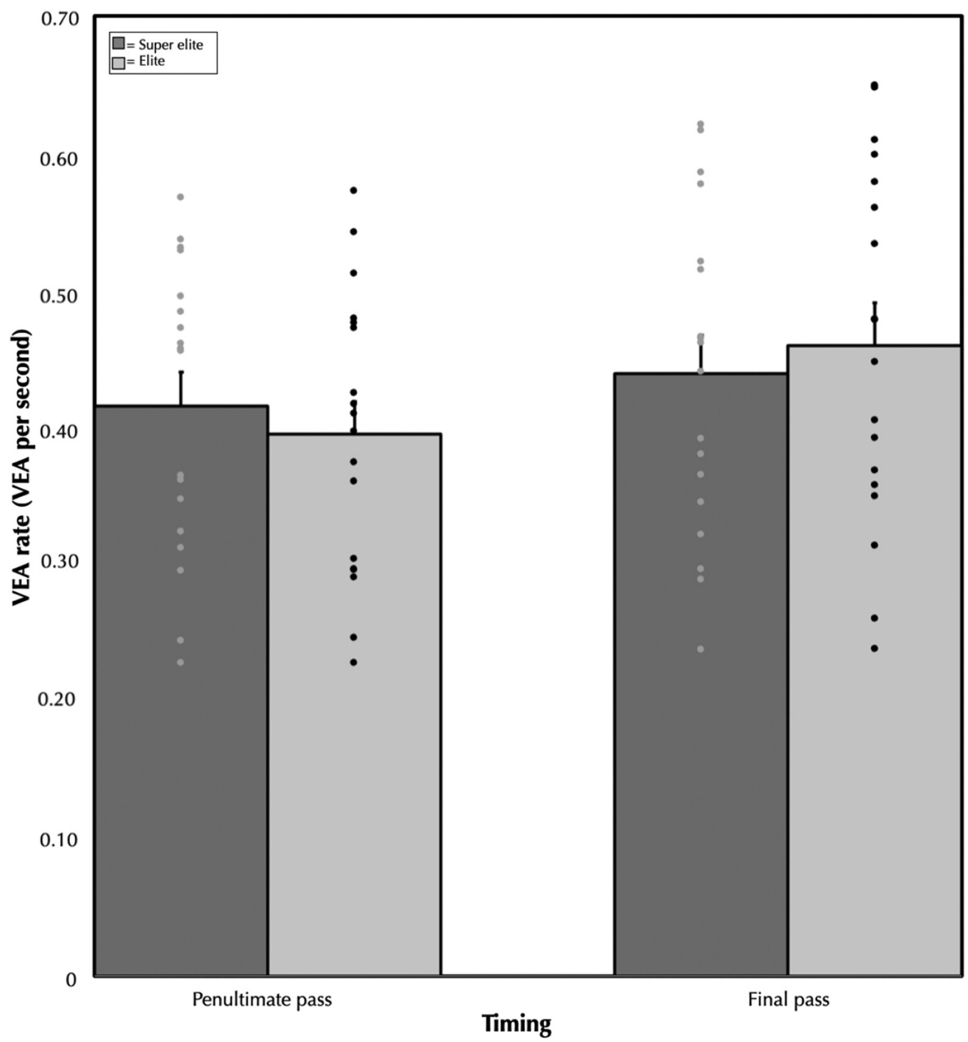

Figure 2. The VEA rate in the penultimate and final pass for the elite and super elite groups.

a significant effect for group, U(36) = 139, z = −.73, $p = .48$, $r = -.07$. The mean for the elite group was 91.9% (SD = 5.9) and for the super elite group 88% (SD = 12.2)(Figure 4).

The relationship between performance and rate of VEA

Model 1 addressed the percentage of adequate ball contacts (Table 2). In the first step, no significant model resulted after entering the rate of VEA in the penultimate pass, F(1,34) = 1.76, $p = 0.19$. Further, also after the addition of the rate of VEA in the final pass the overall model remained nonsignificant, F(2,33) = 1.20, $p = 0.31$. Finally, in the third step, we explored if adding the two interactions between VEA and group would result significantly increase model fit. This was not the case F(2,31) = .47, $p = .63$, while also the overall model remained nonsignificant, F(4,31) = .82, $p = .52$

Model 2 addressed the percentage of adequate subsequent actions (Table 3). In the first step, VEA for the penultimate pass did not yield a significant model, F(1,34) = 2.23, $p = 0.14$. The subsequent addition of the amount of VEA in the final pass in the second step did not result in a significant model either, F(2,33) = 2.32, $p = 0.11$. In the final step, we explored if the two interactions between VEA and group significantly improved the model. However, the inclusion of the two interactions did not significantly increase model fit, F(2,31) = 1.54, $p = 0.23$, and also did not result in a significant overall model, F(4,31) = 1.97, $p = 0.12$. Nonetheless, after bootstrapping the 95% CIs for the VEA in the penultimate pass (4.3–58.5, $p = 0.05$) and the interactions of VEA in the penultimate pass by group (−99.0–13.6, $p = 0.02$) and VEA in the final pass by group (10.1–77.6, $p = 0.03$) did suggest a relationship with the percentage of adequate subsequent actions. Because the overall model is not significant, we refrain from interpreting these further.

Discussion

Football is a multifaced sport that requires players to have a large and diverse skill set to excel. In recent years, growing evidence has been presented showing that VEA are critical in defining skill among football players (Eldridge et al. 2013; Jordet et al. 2013, 2020; McGuckian et al. 2017, 2018, 2020; Phatak and Gruber 2019; Aksum et al. 2021; Pokolm et al. 2022; Caso et al. 2023). To effectively respond to the constantly

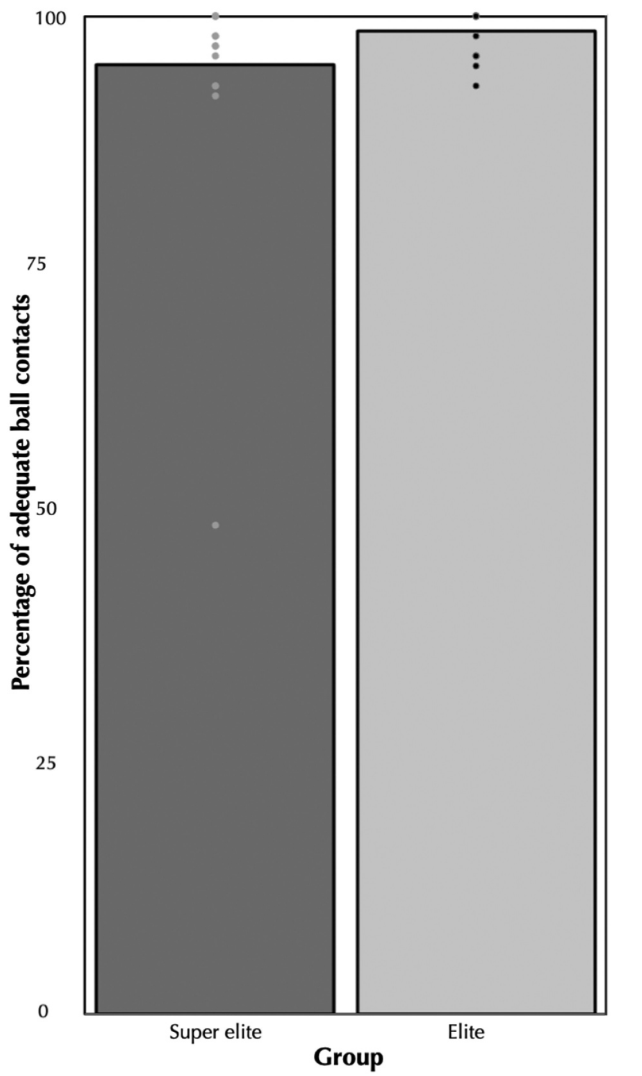

Figure 3. The percentage of adequate ball contacts for the elite and super elite groups.

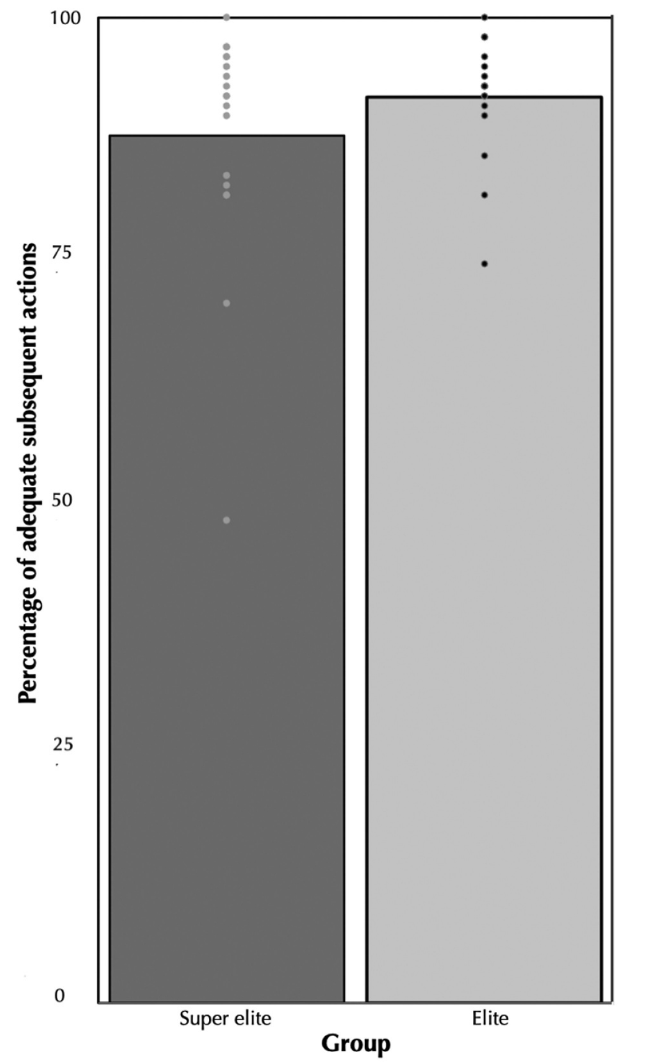

Figure 4. The percentage of adequate subsequent actions for the elite and super elite groups.

evolving environment of a football match, players must consistently and accurately assess the game's shifting opportunities, particularly when anticipating the receiving of the ball. Players do this by using VEA. In general, more skilled players are presumed to exhibit high degrees of VEA compared to less skilled players (Jordet et al. 2020; Aksum et al. 2021; Pokolm et al. 2022). Jordet et al. (2013) suggested that VEA even distinguishes fine-grained skill differences between super elite (i.e., award-winning) and elite players. Within this reasoning, VEA is conceived primarily as a characteristic of the individual

Table 2. Hierarchical regression model for the percentage of adequate ball contacts (Model 1).

MODEL 1	Percentage of Adequate Ball Contacts				
Dependent variable:	B	[BCa 95% CI]	p	R^2	ΔR^2
Step 1				.049 (p = .19)	
Constant	89.3				
VEA penultimate	18.5	[−4.02, 41.3]	.23		
Step 2				.068 (p = .31)	.019 (p = .42)
Constant	87.7				
VEA penultimate	8.4	[−5.3, 22.2]	.29		
VEA final	12.7	[−7.05, 34.1]	.46		
Step 3	87.5			.095 (p = .52)	.027 (p = .63)
Constant					
VEA penultimate	19.2	[−4.03, 42.2]	.22		
VEA final	6.6	[−7.9, 21.4]	.51		
VEA penultimate x Group	−16.8	[−48.7, 16.9]	.48		
VEA final x Group	9.5	[−19.2, 36.8]	.59		

Table 3. Hierarchical regression model for the percentage of subsequent actions (Model 2).

MODEL 2:	Percentage of Adequate Subsequent Actions				
Dependent variable:	B	[BCa 95% CI]	p	R^2	ΔR^2
Step 1				.06 ($p = .14$)	
Constant	80.3				
VEA penultimate	23.7	[−6.3, 54.01]	.14		
Step 2				.12 ($p = .11$)	.12 ($p = .15$)
Constant	77.1				
VEA penultimate	3.7	[−19.4, 26.3]	.75		
VEA final	25.2	[3.02, 48.8]	.06		
Step 3	76.6			.20 ($p = .12$)	.08 ($p = .23$)
Constant					
VEA penultimate	30.9	[4.4, 58.5]	.05		
VEA final	6.3	[−10.5, 24.4]	.52		
VEA penultimate x	−56.2	[−98.9, −13.6]	.02		
Group	43.9	[10.1, 77.6]	.03		
VEA final x Group					

player, although situational constraints, such as the position of a player within a team, have also been shown to affect the rate of VEA (McGuckian et al. 2017, 2018, 2020; Jordet et al. 2020; Aksum et al. 2021; Pokolm et al. 2022; Caso et al. 2023). Therefore, we think that it is pertinent to also factor in the contextual constraints before attributing distinctive rates of VEA (solely) to individual players. Hence, to revisit the fine-grained skill difference between super elite and elite players, we compared VEA of super elite players selected for the UEFA Champions League Squad of the Season 2018–2019 to VEA of their teammates. To control for differences in match dynamics as much as possible, we selected teammates who played the same matches in the same position or line. We hypothesized that the VEA rate would be greater for the super elite group than the elite group, both in the penultimate pass and the final pass before reception. We also expected the super elite group to show more adequate actions after having received the ball and to show a stronger relationship between performance and VEA, especially during the penultimate pass.

The current observations did not support the hypotheses, as VEA was found to not differ between the two groups. Therefore, the super elite players did not distinguish themselves in terms of VEA. This finding suggests that VEA does not differentiate football players across the entire continuum of skill levels, at least not the subtle differences at the high end. However, this does not rule out that larger, less fine-grained skill level variations can be attributed to VEA. Firstly, it is important to consider that the UEFA Champions League competition features the highest European team levels, and most of the observed actions were examined after the group stages, where the number of teams is small, which arguably results in player skill levels being more evenly matched within a team. Almost four out five players in the current sample were playing for the four teams that reached the semifinal matches. Likely, the action repertoire and perceptual skills among these players differs less than that of midfielders from the 20 EPL teams in the study by Jordet et al. (2013). Secondly, it is plausible to suggest that situational constraints (such as match dynamics) play a more crucial role than individual characteristics. Specifically, the tactics employed by teams can have a significant impact on their playing style, which potentially influences VEA. For instance, the level of pressure exerted by an opposing team can influence VEA (Eldridge et al. 2013; Jordet et al. 2020; Aksum et al. 2021, 2021; Pokolm et al. 2022). In addition, situational constraints, such as match tempo and/or speed of play, which may be assessed by determining the frequency of passes, may affect VEA as well. In this respect, it is worth noting that the match tempo or speed of play may vary across competition stages with noticeable differences between the final match of a prestigious tournament like the UEFA Champions League and a group stage match. In brief, to gain a more comprehensive understanding of skill-related differences in VEA, future studies should assess the impact of variations in situational constraints across various levels of skill (or competition).

VEA was significantly greater in the final pass compared to the penultimate pass. These findings are in line with previous research (McGuckian et al. 2018; Caso et al. 2023) which suggests that players execute most VEA just prior to receiving the ball, as in the final pass. However, previous studies also underline the importance of VEA for better performance immediately after receiving the ball (Jordet et al. 2020; McGuckian et al. 2020; Aksum et al. 2021, 2021; Pokolm et al. 2022; Caso et al. 2023). This was not found in the current study, also not for VEA occurring earlier in time during the penultimate pass. Our findings did not provide further evidence that VEA rate is a predictor of the adequacy of ball contact or subsequent actions.[2] Thus, contrary to our expectations, the ability to perform VEA was not proven to be a significant predictor of the adequacy of performance among our sample of elite and super elite players. This may relate to a limited number of observations in our study, and more specifically with the (stringent) inclusion criteria in this study. That is, only possessions where there were two or more passes from teammates in the lead to possession were included. It could be argued that such inclusion is biased somewhat to stable, tactically routinized play. Possibly, the value of VEA would really come in more chaotic, tactically unstructured situations, such as when there are only limited passes before possession, or directly from turnovers. Alternatively, it may be that the super elite players distinguish themselves through other aspects of the game that were not captured within our performance measures. For instance, they may engage in riskier and more penetrative passes, which less directly translate into better team performance.

Our investigation entailed naturalistic observations of high-level football games that lack full experimental control. This is not unlike previous studies (e.g., Eldridge et al. 2013; Jordet et al. 2013, 2020; Phatak and Gruber 2019; Caso et al. 2023). However, our study is the first to try to control for possible differences in situational constraints and especially the dynamics of match. Consequently, we compared VEA between teammates who participated in the same match and played in the same position or the same line of the team (i.e., defense, midfield, or attack). The ensuing similarity is a significant methodological improvement compared to previous studies, although obviously the situational constraints were not identical for the players assigned to the super elite and elite groups. In this respect, it is also pertinent that group assignment was uniquely based on performance during the 2018–2019 season, while players who were selected for the UEFA Champions League Squad of the Season in previous seasons can arguably also be considered outstanding and super elite. We were limited in the amount of video footage we had available. Together with the relatively strict inclusion criteria to enhance control of situational constraints, this resulted in a relatively small sample size. Consequently, the study must be considered exploratory, and care must be taken not to overinterpret the current observations. Nonetheless, it seems worth the effort to conduct a large study across the entire range of skill (and/or age) levels and that factors into variations in situational constraints. This would also be of critical importance when striving to utilize VEA for identification and development of talented players. Finally, it should be noted that head and body movements away from the ball vary systematically with the spatial and temporal unfolding of the game, and these movements serve as a proxy for the visual exploration of affordances rather than the actual pickup of optical information (Gibson 1979). To enhance our understanding of these exploratory activities, gaze tracking techniques can be employed (McGuckian et al. 2018). Yet, because football regulations prohibit the use of equipments such as gaze trackers during official matches, video-recordings and gaze tracking during training matches (Aksum et al. 2021), possibly combined with inertial measurement units to measure head movements (McGuckian and Pepping 2016; Chalkley et al. 2017) could be used to create and validate algorithms that automatically estimate gaze direction from video-footage.

To conclude, we demonstrate that the rate of VEA differs significantly between different stages of passing but does not distinguish the super elite from elite players. Moreover, no evidence was found that VEA is associated with performance adequacy among the selected pieces of game play in the current sample of elite and super elite players.

Notes

1. For 5 out 18 super elite players, no teammate was available that played in the same position. For these players, we selected a teammate that played in the same line instead (see Methods for further details).
2. It should be noted that the analysis for the percentage of adequate subsequent actions hinted at the relevance of VEA during the penultimate pass, possibly depending on the group, but given that model fits were not significant, these findings need to be substantiated before we can interpret them reliably.

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Data sharing statement

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Data availability statement

Data would be provided upon request.

Open scholarship

This article has earned the Center for Open Science badge for Open Data. The data are openly accessible at https://doi.org/10.34894/LHOGF6.

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