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Abstract

Purpose: Examine visual function of soccer players of different skill level and playing position.

Methods: Elite players from an English Premier League soccer club (n=49) and intermediate players (n=31) completed an assessment on a Nike SPARQ Sensory Station of: static and dynamic visual acuity, contrast sensitivity, accommodative-vergence facility, target capture and perception span.

Results: There was no difference between elite and intermediate players for all measures. However, competitive soccer players (elite, intermediate) did exhibit better performance in acuity-based measures of visual function and accommodative-vergence compared to a population of healthy non-athletic adults (n=230). With regards to player position, defensive players showed quicker accommodative-vergence facility compared to offensive players.

Conclusion: Visual function of competitive soccer players is superior to non-athletic adults, but does not differentiate the elite and intermediate player. However, defensive players do exhibit faster accommodative-vergence than offensive players. We suspect that this particular visual function is advantageous for defenders given the greater demand to continually shift gaze between players located at near and far locations.

Key words: visual function, soccer, elite, playing position, accommodative-vergence

Introduction

The importance of vision and related processes (e.g., oculomotor control) in sport has long been explored and led many to suggest that enhanced visual function facilitates performance (Ciuffreda & Wang, 2004; Faubert & Sidebottom, 2012; Gao et al., 2015, Hazel, 1995; Poltavski & Bidedorf, 2015; Voss, Kramer, Basak, Prakash, & Roberts, 2010). For this reason it has been recommended that athletes have regular visual function assessment (Erickson, 2007) and undertake vision training as part of their overall developmental program (Clark, Ellis, Bench, Khoury, & Graman, 2012; Deveau, Ozer, & Seitz, 2014; Kim, Seitz, & Watanabe, 2015). However, it is not unanimously accepted that better than normal visual function (e.g., static acuity, dynamic acuity, peripheral awareness) is essential to athletic performance (Abernethy & Wood, 2001), with researchers suggesting context-specific processes (e.g., field-based anticipation and decision-making) are more important in differentiating experts from novices (Abernethy, Gill, Parks, & Packer, 2001; Williams, 2000).

In reviewing the literature on visual function and training in sport, Hazel (1995) suggested that equivocal findings could be explained by the definitions used to determine group membership (for related issues of inter-participant variability, see Ward & Williams, 2003), as well as comparisons of various sports that have different visual requirements and a lack of consideration for the individual demands of player position. Indeed, while it is well accepted that the physical characteristics and demands placed on athletes such as soccer players differ as a function of playing position (e.g., Reilly, Bangsbo, & Franks, 2000), there has been limited consideration regarding visual function (for examples from other sports see Wimshurst, Sowden, & Cardinale, 2012; Klemish et al., 2017). This is surprising, particularly in invasion sports, where player position dictates a performer's tactical role and thus the types of behaviour required in a given situation. For example, in soccer an offensive player is primarily tasked with invading the opponent's territory in order to score, whereas a defensive player attempts to contain space and regain ball possession to avoid conceding goals. Thus, it is conceivable that the demands of player position in soccer may coincide with specific visual abilities.

In the current study, we explored the visual function of English premier league (first team and U-21) and intermediate-level soccer players (university scholars and varsity-standard), who had predominantly defensive (goalkeepers/defenders) or offensive (midfielders/forwards) roles. Importantly, this is the first study to provide a comprehensive assessment of visual function in a group of elite soccer players, who perform at the highest level for a club in the English premier league. We assessed a range of visual functions that are considered (Erickson, 2007) important for sport performance (i.e., static and dynamic visual acuity, contrast sensitivity, accommodative-vergence facility, perception span, target capture). Following a comparison of the visual function of soccer players (elite vs. intermediate), we made a further comparison between these data and those from a large-scale assessment of a healthy non-athlete adult population using the same apparatus (Wang et al., 2015).

Given the exploratory nature of the study and the novelty of the sample, we did not have explicit hypotheses regarding the visual function of elite compared to intermediate level soccer players (see also Klemish et al., 2017). However, in accord with the general finding that athletes have better visual function than non-athletes (Gao et al., 2015; Hazel, 1995), we did expect competitive soccer players (elite and intermediate) to perform better on a number of visual assessments compared to normative data. Finally, we anticipated that any player position differences in visual function would reflect the tactical roles of offensive compared to defensive players.

Method

Participants

There were 49 expert players from an elite-level premier league soccer club (first team n = 21, under-21/reserve n = 28), and 31 intermediate-level players undertaking a soccer scholarship program (n = 15) or competing for their university at varsity standard (n = 16). The cohort included goalkeepers/defenders and midfielders/forwards, which were each split into defensive and offensive groups, respectively (elites-defensive n = 24, elite-offensive n = 25, intermediate-defensive n = 10, intermediate-offensive n = 21). The mean age was 21 years and 7.5 months (age range between 16 and 39 years). If required, participants were to arrive for testing with their corrected vision eyewear. None of the participants indicated any perceptual or neurological comorbidities, and all gave consent to participate in a protocol that was approved by the host University's ethics review committee.

Apparatus and Task

Visual function was assessed with a Nike Sensory Station (Nike Inc., Beaverton, OR) consisting of a central computer controlling two high resolution liquid crystal display monitors (55 cm diagonal display; 105 cm touch-sensitive diagonal display with the height adjusted to player eye-level). An Apple iPod touch® (Apple Corporation, Cupertino, California) was wirelessly connected to the central computer and provided input for several of the visual assessments. Custom proprietary software controlled the stimulus displays, input response and data recording. Pre-recorded instructions combined with visual demonstrations were issued prior to each assessment with the option to replay upon request of the participant. Participants were instructed to closely follow both the instructions and demonstrations. Prior to assessment they received practice trials to become fully aware of the task procedure.

Assessments

Participants completed a total of nine assessments, which took a maximum of twenty five minutes (for more detail see Erickson et al., 2011; Wang et al., 2015). However, with the cohort of soccer players studied here, we were only interested in the assessments of visual function and not those that depended on a speeded response from the upper limb. Acuity-based assessments (i.e., visual clarity, contrast sensitivity, depth perception[1], near-far quickness, target capture) involved participants standing 4.8 m (16-ft) perpendicular to the sensory station, from where they gave their response using the iPod touch. Perception span required participants to select targets that were presented at arm's length from the touch screen.

Visual Clarity measured participants' discrimination of a static optotype (i.e., Landolt ring). Stimuli were presented at screen centre with a gap missing at top, bottom, left or right. Participants were instructed to swipe on the iPod touch device in the direction of the gap. The size of the ring was increased or decreased depending on the selection of correct responses as determined by custom proprietary staircase reversal algorithm. Visual clarity was completed in both monocular and binocular viewing conditions, although only the latter is reported.

Contrast Sensitivity measured the ability to detect differences in brightness at particular spatial frequencies. An array of four black outline circles was presented, one of which contained a concentric ring pattern that varied in brightness and spatial frequency (6 or 18 cycles per degree) in accord with a reversal staircase algorithm. Participants had to swipe in the direction of the circle containing the concentric ring pattern.

Near-Far Quickness measured the speed of accommodative-vergence facility as the participant made binocular saccadic responses to images presented at near and far distances. A black Landolt ring was alternately presented on the liquid crystal display (0.1 log units above acuity threshold; see measure of Visual Clarity) and the iPod touch screen (acuity equivalent to 20/80) for 30 seconds. Participants were instructed to swipe in the direction of the gap. Successive stimuli were presented only after a correct response was given.

Target Capture provided a measure of dynamic visual acuity. Participants initially focused on a central black fixation dot at the centre of the screen. A Landolt ring then appeared in one of the four corners of the screen (0.1 log units above acuity threshold) at 52 cm from the fixation dot (visual angle of 6.18º). Participants made a binocular saccadic gaze shift to the target in order to identify the direction of the gap, which was recorded by swiping on the iPod touch screen. The Landolt ring presentation time decreased following a correct response. The time where the gap could be successfully identified was recorded as threshold.

Perception Span measured the visual information that performers could process and recall following a limited time period. An array of unfilled circles (19-mm diameter) was presented surrounding a black fixation dot at screen centre. A series of dots then appeared in a select number of the circles for a period of 100 ms. Participants were instructed to recall the number and location of the dots by touching the screen in corresponding circles. The number of dots and circles were increased following a correct response. The total number of correct dot selections was recorded at a 75% correction threshold.

Data Management and Analysis

The dependent measures featured equal between-group variances across the groups (*ps* > .05) (Levene's test). The primary data analysis involved a 2 Level (elite, intermediate) by 2 Position (offensive, defensive) between-measures Analysis of Variance. Significant interaction effects were decomposed using Tukey HSD post hoc procedure. Significance for all statistical tests was declared at $p < .05$.

Results

The group mean and standard deviation data are shown in Table 1. For all but one of the measures, there was no significant main effect of level and position, nor a level by position interaction (*ps* > .05). There was, however, a significant main effect of Position for near-far quickness, $F(1,76) = 4.48$, $p < .05$, *partial* $\eta^2 = .06$, indicating faster accommodative-vergence facility in defensive compared to offensive players.

[Insert Table 1 about here]

While there were no differences between elite and intermediate-level soccer players, it would be premature to conclude that better than normal visual function is not important to soccer performance. Therefore, using one-sample z-tests, we compared the entire group of soccer players (n = 80) with normative data taken from the healthy non-athlete adult population (n = 230; 105 males, 125 females) that were tested with the same apparatus (Wang et al., 2015). The group means and standard deviation data are shown in Table 2. The results indicated that soccer players had superior performance compared to non-athletes for visual clarity ($z = 3.41$, $p < .01$, $d = .53$), contrast sensitivity at 6CPD ($z = 3.49$, $p < .01$, $d = .45$), contrast sensitivity at 18CPD ($z = 5.91$, $p < .01$, $d = .89$) and near-far quickness ($z = 6.06$, $p < .01$, $d = .60$). There were no significant differences for target capture ($z = .60$, $p > .05$, $d = .04$) and perception span ($z = 1.17$, $p > .05$, $d = .13$).

[Insert Table 2 about here]

Discussion

The present study examined the visual function of soccer players of different skill level (elite, intermediate) and playing position (defensive, offensive). Across a range of assessments of visual function in a context-free setting (i.e., Nike SPARQ Sensory Station), we found no differences between our elite and intermediate players. The lack of skill level effect in visual function extends upon previous work that has reported no differences between soccer players of generally lower skill levels for measures including, static and dynamic visual acuity, saccadic response speed and peripheral field (semi-professional vs. recreational; Helsen & Starkes, 1999, elite youth vs. recreational youth; Ward & Williams, 2003). Importantly, however, this is the first study to provide a comprehensive assessment of visual function in a large sample of full professional soccer players performing at the highest possible standard.

In terms of player position, we found that speed of accommodative-vergence facility (as indicated by near-far quickness) was significantly better in defensive than offensive players. Being able to quickly shift gaze and refocus between near and far locations is said to be important in dynamic sports (Ciuffreda & Wang, 2004; Coffey & Reichow, 1990; Coffey & Reichow, 1995; Gao et al., 2015), and has been shown to differentiate volleyball players (advanced vs. intermediate) from non-players (Jafarzadehpur, Aazami, & Bolouri, 2007), as well as being a predictor of actual performance in Division 1 ice-hockey players (Poltavski & Bidedorf, 2015). Results from a general vision training experiment with Olympic-level field hockey players, found that goalkeepers (i.e., defensive playing position) exhibited the greatest improvement in a "focus flexibility" task, which involved shifting gaze between near (arm's length) and far (3m) distance to read optotypes (Wimshurst et al., 2012). The authors explained this effect with reference to the fact that goalkeepers in hockey spend much more of the game moving their eyes around the pitch to follow the ball, and thus benefitted from training on a task requiring a continual change in near-far focus. An alternative interpretation is that differences in near-far quickness could have been related to an asymmetrical prevalence of abnormalities in basic oculomotor functions. While prudent to assesses vergence and accommodation in future work, it is notable that a Levene’s test (see Methods: Data Management and Analysis) on the current data indicated <20% unit difference in the Coefficient of Variation between groups, and thus no significant difference in within-group variance. In addition, it is also possible that that there could have been some influence of selection bias as a result of forming the groups of defensive and offensive players from the entire sample (i.e., not randomly allocated). Replication of the current study with a wider range of players and clubs is therefore warranted.

In soccer, differences in the demands of defensive and offensive playing position are likely to influence gaze location. Defensive players are responsible for ensuring that the ‘offside trap’ is not broken, and thus need to quickly change the gaze location in order to perceive and coordinate with other team-mates whilst remaining vigilant of opposing players. This contrasts with offensive players who benefit from looking at the best possible option to increase the chances of scoring (i.e., pass, dribble, shoot), and thus do not need to make as many gaze changes between near and far locations. Empirical support for a difference in gaze location as a function of the situational demands on defensive play in soccer has been reported in video simulations (Roca, Ford, McRobert, & Williams, 2013). For instance, when a skilled player occupied a defensive viewpoint far from the ball, they exhibited a larger number of short-duration fixations to surrounding opposing players and team mates. However, when the defensive viewpoint was located near to the player with the ball, skilled participants made a small number of long-duration fixations that were focused on that player. The authors suggested that visual search behaviour (i.e., changing gaze location) combined with context-specific cognitive processes (e.g., pattern recognition) underpins the superior anticipation and decision-making of expert soccer players.

Of interest, the results also indicated that our cohort of soccer players (elite and intermediates) were significantly better than the population of healthy non-athletic adults on all measures of visual function except target capture and perception span. The lack of difference between groups in target capture could appear surprising given that soccer involves interaction with a rapidly moving ball and surrounding players. However, it is questionable whether the ability to respond with a binocular saccadic gaze shift to the sudden appearance of a static optotype provides an adequate test of dynamic visual acuity demands in invasion sport (Poltavski & Bidedorf, 2015). As for perception span, which requires the individual to divide attention and remember the location of stationary objects, there is a lack relevance to the dynamic visual environment experienced by soccer players. Indeed, it is more likely that being able to keep track of multiple objects moving in depth is an important visual function for elite soccer players (Faubert, 2013).

While our comparison between soccer players and normative data did not take into consideration the fact that the latter included both males and females, it has been reported that this individual difference is more likely to influence measures involving coordinated and speeded hand movements rather than visual sensitivity and oculomotor control (Wang et al., 2015). Therefore, a reasonable explanation for the group differences reported here is that the demands of soccer, whether playing in a defensive or offensive position at an elite or intermediate level, do in fact favour participants with visual function that exceed those of healthy non-athletic adults. This conjecture is consistent with a number of studies that have reported differences in a range of visual abilities when expert athletes are compared with non-athletes (Di Russo, Pitzalis, & Spinelli, 2003; Faubert, 2013; Gao et al., 2015; Overney, Blanke, Herzog, & Burr, 2008; Voss, Kramer, Basak, Prakash, & Roberts, 2010).[2] An interesting issue for future work will be to determine if some of the advantages in competitive soccer players are related to more regular uptake of eye examination and use of optimal visual correction.

In terms of practical implications, there is growing evidence that aspects of both general visual function and specific visual processing abilities can be improved through training (for reviews see Appelbaum & Erickson, 2016; Page, Causer, Wilson, Gray, & Williams, 2013). For instance, accommodative-vergence facility was improved in both healthy non-athletic adults (Krasich, Ramger, Holton, Wang, Mitroff & Appelbaum, 2016) and intermediate-level University softball players (Appelbaum, Lu, Khanna & Detwiler, 2016). However, these same authors found that measures of visual sensitivity (i.e., visual clarity and contrast sensitivity) did not improve with specific practice (cf. Deveau, Lovcik & Seitz, 2014). Based on these and other findings in invasion sports (Wimshurst et al., 2012), it would seem worthwhile to both assess accommodative-vergence and devise training programmes when there is need for improvement. Such training programmes should consider the extent to which the underlying dynamics and timing of accommodative-vergence can be improved using stimuli with high fidelity to the physical (Harle & Vickers, 2001; Page et al., 2013) or cognitive (Faubert & Sidebottom, 2012; Romeas, Guldner, & Faubert, 2016) demands of specific soccer player positions (Vaeyens, Lenoir, Williams, Mazyn, & Philipaerts, 2007).

In summary, these are the first data to show that while elite and intermediate soccer players do not differ in various measures of visual function, soccer players do exhibit better visual performance than the population of healthy non-athletic adults. In addition, we found that defensive soccer players have a faster accommodative-vergence facility compared to offensive players. Together, these findings suggest gaze control could be important in dynamic invasion sports, where it is necessary to move the eyes and thus attention in an optimal way to facilitate perception of relevant information.

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Disclosure of interest

Nike Inc. did not contribute to the production of the report. There is no conflict of interest.

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Table 1. Mean data (± SD) as a function of level (experts, intermediate) and position (defensive, offensive) (visual clarity (ft. log transform), contrast sensitivity (6CPD, 18CPD) (% log transform), near-far quickness (number of correct responses), target capture (ms), perception span (number of dots). (*****) indicates an effect of position.

	Experts		Intermediate	
Measure	Defensive	Offensive	Defensive	Offensive
Visual Clarity	-.21 (.10)	-.20 (.12)	-.20 (.14)	-.19 (.09)
Contrast Sensitivity: 6CPD	2.28 (.19)	2.20 (.24)	2.19 (.22)	2.26 (.21)
Contrast Sensitivity: 18CPD	1.62 (.20)	1.66 (.21)	1.60 (.13)	1.64 (.24)
Near-Far Quickness *	29 (5)	25 (7)	29 (4)	27 (6)
Target Capture	305 (129)	299 (148)	280 (164)	275 (108)
Perception Span	38 (13)	35 (13)	39 (9)	36 (8)

Table 2. Mean data (± SD) for soccer players (n=80) and non-athletes (n=230) (visual clarity (ft. log transform), contrast sensitivity (6CPD, 18CPD) (% log transform), near-far quickness (number of correct responses), target capture (ms), perception span (number of dots). (*****) indicates a significant difference.

Measure	Soccer players	Non-athletes
Visual Clarity *****	-.20 (.11)	-.14 (.15)
Contrast Sensitivity: 6CPD *****	2.24 (.22)	2.14 (.25)
Contrast Sensitivity: 18CPD *****	1.64 (.21)	1.45 (.28)
Near-Far Quickness *****	27 (6)	24 (5)
Target Capture	292 (133)	287 (132)
Perception Span	37 (11)	38 (11)

Footnote

1. Responses to the depth perception test could not be analysed due to technical difficulties.

2. It could be relevant to assess some visuomotor abilities in goalkeepers, but here we did not have a sufficient number to form a group (n=8). Observation of their data indicated values that were within the boundaries of the distribution obtained by outfield players (Eye-hand Coordination: goalkeeper range = 46.8-55.4, outfield M = 53.0 (± 3.5), Reaction Time: goalkeeper range = 329-385 ms, outfield M = 357 ms (± 34), Response Time: goalkeeper range = 402-640 ms, outfield M = 443 ms (± 64). Future work, potentially involving the pooling of data from across premier league clubs or similarly elite goalkeepers, is required before any firm conclusions can be drawn.