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Pre-print

Testing the validity of 360-video for analysing visual exploratory activity in soccer

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Testing the validity of 360-video for analysing visual exploratory activity in soccer

Extended reality (XR) technologies present new opportunities to measure sports performance in immersive and representative environments. Viewed through head-mounted displays (HMDs), 360-video offers the opportunity to capture visual exploratory activity (VEA) using representative stimuli in controlled scenarios. This study aimed to i) assess the construct and face validity of a 360-video simulation for capturing VEA in women's soccer and ii) understand players' perceptions of acceptability and tolerability of the simulation. Footage was recorded using a stationary GoPro 360 Max camera at eye height in six pitch locations. VEA was measured by the number of 'scans' away from the ball before the ball reached the 360-video camera. Eleven sub-elite women's soccer players and eleven novices viewed 40 soccer videos in a HMD, with videos ending after a pass from a teammate. Upon receiving the pass, participants verbalised and acted an action response. Participants answered open-ended questions on acceptability, physical fidelity, and tolerability. Results supported construct and face validity, with good acceptability, tolerability, and physical fidelity. Soccer players (*Mdn* = 0.31 scans/s) had significantly higher scan frequencies than novices (*Mdn* = 0.06 scans/s, $p < 0.001$) and generated significantly more detailed responses per trial ($p < 0.001$). 360-video offers a valid and acceptable method for capturing VEA and has potential to offer new measures for talent identification processes. Future work should focus on efficacy of 360-video for skill development.

Key Words: immersive, scan frequency, women's football, visual perception, virtual reality, simulation.

Introduction

In soccer, players must effectively process surrounding information to select the most appropriate action (Pagé et al., 2019). This process relies on effective visual exploratory activity (VEA), defined as a head or body movement where a player's face is temporarily directed away from the ball to locate teammates, opposition players or empty space, before engaging with the ball (Jordet et al., 2020). Studies have found positive relationships between VEA and pass completion rates in youth men's (Aksum, Pokolm et al., 2021; Pokolm et al., 2022), professional men's (Jordet et al., 2013), and women's soccer (Feist et al., 2024). Skilled players frequently scan their environment to identify nearby opponents, teammates, and potential passing options (Pokolm et al., 2022). However, research into VEA in experimental settings remains limited. One study presented 12 male soccer players with video scenarios on four computer screens positioned behind them, requiring them to identify a "free teammate" after observing a pass on a front-facing screen (McGuckian et al., 2019). Results showed that time constraints significantly influenced head movements as well as a significant relationship between head movements and the speed of a simulated passing response (McGuckian et al., 2019). Whilst this was a novel design, the study's use of multiple screens lacked realism, highlighting the need for more representative tools. Emerging XR technologies such as 360-video (Höner et al., 2023) and Virtual Reality (VR; Wirth et al., 2021; Wood et al., 2021) present promising avenues for training and testing VEA.

360-video is a video recording technique where all directions are recorded at the same time (Kittel et al., 2023). When displayed via a head-mounted display (HMD) users can scan representative environments and change their viewpoint with their head movements (Lindsay et al., 2023). Unlike traditional video, 360-video enables participants the opportunity to explore game-based situations as if they were players in the game (Musculus et al., 2021). This technology has increased the opportunities to study perceptual-cognitive skills such as decision-making in cricket (Discombe et al., 2022), basketball (Pagé et al., 2019), soccer (Höner et al., 2023; Musculus et al., 2021) and boxing (Taupin et al., 2023). Research has utilised 360-video to assess in-game decision-making in soccer, showing that 24 male soccer players rated the motivational effect, acceptability and immersion positively, highlighting benefits of HMDs (Höner et al., 2023). Although the terms 360-video and VR are often used interchangeably, they are separate platforms with different functionality. VR is a computer simulated environment that requires time and programming expertise to develop, which is typically beyond the capacity of many sporting organisations (Panchuk et al., 2018).

Although 360-video sacrifices interactive elements it can be produced at much lower costs and provides an immersive view of the real world that athletes rate highly for the ability to visually explore a realistic environment (Runswick, 2023). Therefore, 360-video appears to be practical technology for measuring visual exploratory activity.

Despite multiple experimental studies investigating VEA in male soccer (e.g., McGuckian et al. 2019; Aksum, Brotangen et al., 2021), understanding of VEA in women's soccer remains limited. Research in women's soccer has focused on the technical and tactical demands of the game (de Jong et al., 2020; Kubayi & Larkin, 2020), with differences found in ball possession tactics between successful and unsuccessful teams (Dipple et al., 2022; O'Donoghue & Beckley, 2023). Successful teams have been found to be more centralised, performing more effective ball movements and transfers (de Jong et al., 2022). An observational study of VEA in elite women's central midfield players which analysed 30 central midfield players during the knock-out stages of UEFA Women's EURO 2022 (Feist et al., 2024). The study found higher scan frequencies significantly predicted more successful actions with the ball. Scan frequencies were significantly higher in central defensive midfield pitch locations, compared with attacking or wide locations (Feist et al., 2024). In light of these findings, understanding how to measure and train VEA appears crucial. This would help to develop players' ability to explore their environment effectively and guide subsequent actions with the ball.

Following Harris et al.'s (2020) framework for validating simulated environments, an evidence-based approach to developing 360-videos which ensures construct validity (accurately reflecting performance differences; Harris et al., 2021) and face validity (true representation of the task; Bright et al., 2012) is required. Examining construct validity in 360-video is crucial to provide an objective measure of a simulated test's ability to capture elements of sporting performance across skill levels (Harris et al., 2020). Birckhead et al. (2019) provides a methodological framework which assesses users' perceptions of acceptability and tolerability of a simulation. Acceptability refers to a user's willingness to try the technology, while tolerability addresses any underreported emotional or physical effects, typically assessed via questions regarding simulation sickness (Birckhead et al., 2019). Understanding these factors is the first step for the use of 360-video to capture VEA in women's soccer. The present study aims to i) assess the construct and face validity of a 360-video simulation for capturing visual exploratory activity in women's soccer, and ii) understand players' perceptions of acceptability and tolerability of a 360-video simulation in women's soccer. For construct validity, we hypothesise that sub-elite women's soccer players will have significantly higher scan frequencies compared to novices. We further hypothesise that soccer players will provide more varied and detailed verbal descriptions of their next intended action compared to novices.

Method

Participants

An *a priori* power analysis was conducted using G*Power (version 3.1; Faul et al., 2007) and the effect size (Hedge's g = 1.13) for distinguishing competitive and social soccer players on a soccer skills test reported by Runswick et al. (2022). With a one-tailed α of 0.05, a power (1-β) of 0.80, a minimum sample size of 20 (10 participants per group) was required to detect this effect. Eleven sub elite female soccer outfield players (*M* age = 22, *SD* = 5 years) and eleven novices (*M* age = 20, *SD* = 2 years) were recruited, with expertise classified based on Swann et al.'s (2015) continuum. Inclusion criteria required participants to be over 16 years of age; report normal or corrected to normal vision and be injury-free. Sub-elite outfield soccer players currently competed in Tier 6 or higher in the English women's football pyramid. Novices had no experience of playing any form of competitive soccer. Ethical approval was obtained from the lead author's institution and written informed consent was provided by all participants, including those featured in the video stimuli.

Filming 360-video soccer stimuli

360-video footage was created by filming 9v9 and 7v7 soccer training matches (see Figures 1 and 2). Compared to competitive 11v11 matches, these reduced player numbers allowed all players to be clearly visible in the HMD (see Höner et al., 2023). All visual stimuli were recorded on three-quarters of a full-size pitch using a Go-Pro 360 max (30FPS at 5.6k) camera positioned in central areas of the pitch on a stationary tripod at eye height (1.68 m from the ground). Pedersen et al. (2019) reported the average height of women in their sample to be 168cm. Therefore, based upon this finding and that of other similar studies camera height (Runswick, 2023; Kittel et al. 2019), the camera was placed 1.68m above the ground at 'eye height'. This camera angle provided a first-person perspective in the HMD to enhance the sense of being in the game itself.

As shown in Figure 1 and 2, the GoPro 360 max camera was positioned in four pitch locations: defensive midfield centre left (DMCL), defensive midfield centre right (DMCR), attacking midfield centre right (AMCR) and attacking midfield centre left (AMCL). For each location, the ball began in one of three positions: (1) with the right back, (2) with a throw-in taken by the left back in a defensive midfield location of the pitch or (3) at the feet of the striker in a central attacking pitch location. These starting locations reflected frequent scenarios from the UEFA Women's EURO 2022 based upon findings from Feist et al. (2024). Players received contextual information about the match (0-0; first half) and were instructed to perform as if they were in a competitive match. Play began with the 'in-possession' team (orange bibs) which aimed to pass the ball towards the tripod (with the intention of hitting the tripod). Once a pass struck or came within 1 metre of the tripod, players continued until a whistle signalled the scenario's end. A total of 108 scenarios across four pitch locations were recorded over four sessions. The lead author reviewed all scenarios, excluding trials in which possession was lost before reaching the camera. Five trials where possession broke down before reaching the camera were randomly selected as 'washout trials' for the final testing video. In total, forty scenarios (twenty 9v9 trials and twenty 7v7 trials) were selected including the five 'washout' trials where possession ended without requiring participant responses. These trials were included to ensure participants remained engaged in the task, but intended actions were recorded for the 35 trials where participants 'received' the ball.

Figure 1

Schematic illustration of the 9 vs 9 soccer training game. The central midfield player (orange cross located in the white circle) represents the position of the 360-video camera.

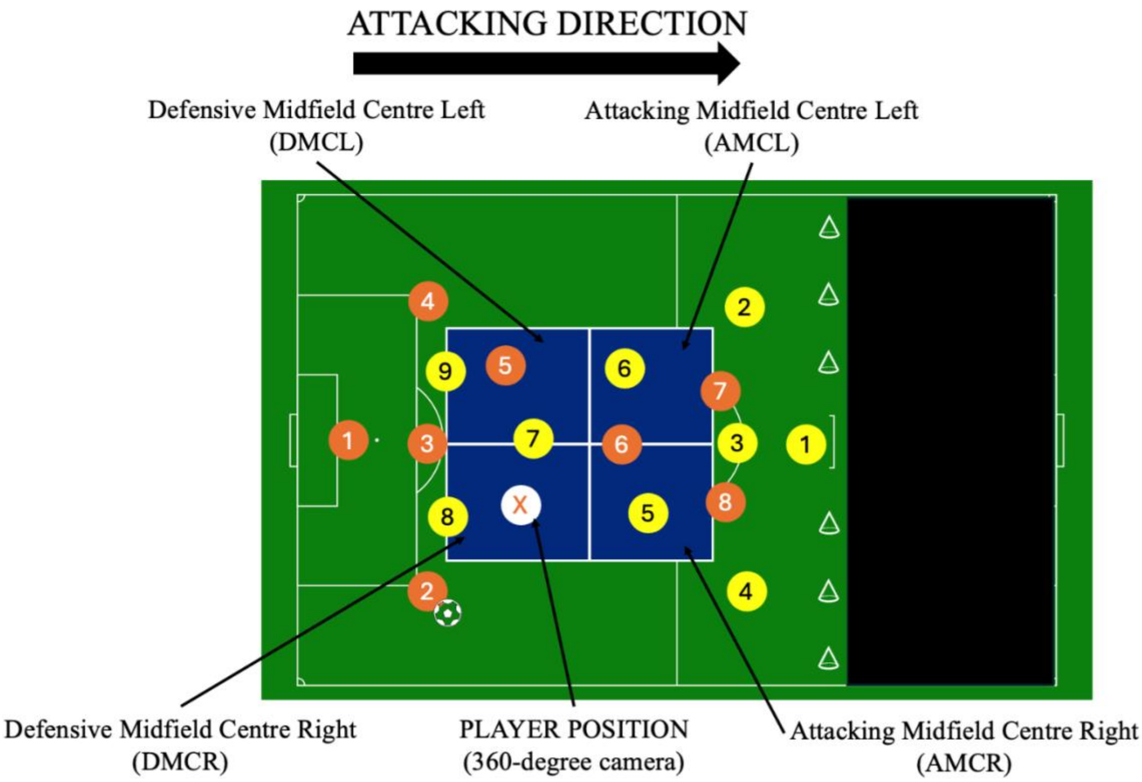
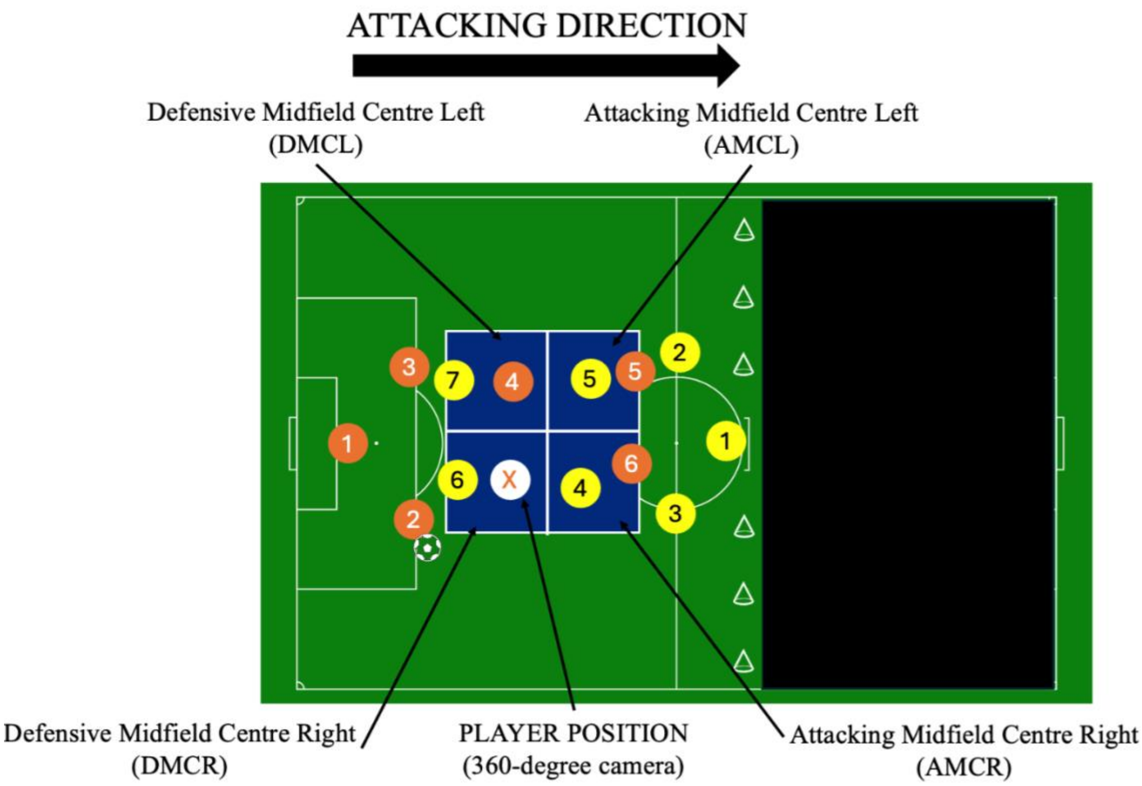


Figure 2

Schematic illustration of the 7 vs 7 soccer training game. The central midfield player (orange cross located in the white circle) represents the position of the 360-video camera.



After selecting the final testing scenarios, videos were imported into Adobe Premier Pro (San Jose, CA, USA) to create two larger testing videos: one 7v7 video and one 9v9 video. The videos had a mean duration of eleven minutes and one second. Based on pilot testing, videos were edited to include a five second freeze frame at the beginning, showing the football starting location and attacking direction. Scenario order (pitch location and ball starting locations) was randomised, but remained consistent across participants (Discombe et al., 2022).

Apparatus

All trials were presented through a HMD (Meta Quest 2) connected to a ASUS G533QS gaming laptop. An adapted strap was used to tightly secure the headset on participants. Trials were played through SkyBox VR on the Meta Quest 2.

Procedure

All participants attended a single testing session and wore sports clothing, indoor sport trainers, and an orange bib as they would play as a member of the orange team. Participants viewed two separate three minute videos (an operational definitions video and a testing instructions video) in the HMD while standing. Following this, participants completed five self-guided practice trials, similar to that of Höner et al. (2023), to familiarise themselves with the viewing perspective and task requirements (Murphy et al., 2018). Participants were instructed to imagine themselves as a player on the pitch and to observe each scenario until the trial ended.

In thirty-five trials, participants received a pass and were instructed to perform a ‘shadow’ action with the ball (‘mime’ a physical action of their intended action), similar to Roca et al. (2013) and Discombe et al. (2022) where soccer players mimed soccer actions and batters mimed a ‘shadow’ cricket shot, respectively. After performing their ‘shadow action’, participants verbalised their intended action with the ball and were presented with a list of potential ‘actions’ to provide guidance: ‘Pass’, ‘dribble’, ‘shoot’, ‘receive and protect the ball’, ‘turn with the ball’ and ‘unsure’. For example, a participant might respond verbally, “I would turn with the ball and pass to the left winger”. Participants completed forty trials split into two separate blocks of twenty 9v9 trials and twenty 7v7 trials with a five-minute seated rest between blocks (similar to that of Musculus et al., 2021). The entire procedure lasted 60 minutes.

Actions were recorded in both the real-world (using a Go-Pro Hero 4, 30FPS at 720p) and the 360-video environment (using QuickTime player on an Apple MacBook Pro, Version 12.6.3). All trials were analysed using the first person Oculus Footage, with 20% cross-checked against the external Go-Pro footage. After completing the forty trials, participants completed an adapted presence questionnaire (Witmer et al., 2005) and answered open and closed questions to understand the face validity, acceptability, and tolerability of the task. Participants were also asked if they would be interested in using 360-video for future training and testing.

Measures

Scan frequency. The total number of scans over the final 10 seconds before the ball reached the 360-video camera divided by the elapsed time (Feist et al., 2024).

Scan timing. The time in seconds before trial end when players scanned their environment (Feist et al., 2024). Data is presented as mean scan frequencies across the final five seconds prior to participants receiving the ball in the video.

Action Type. The type of action with the ball verbalised by participants summarised as frequency scores for both groups. Presented as frequency scores.

Action Detail. For every action type, ‘action detail’ was recorded capturing additional information provided in their response. For example, if a player responded, “I would turn with the ball, dribble down the left wing and cross the ball”, the recorded action type would be ‘turn with the ball’ with two additional action details (‘dribble’ and ‘cross’). This measure is presented as frequency scores.

Number of actions generated per trial. Dividing the total number of actions verbalised by the number of trials completed.

Number of action details generated per trial. Dividing the total number of additional action details verbalised by the number of trials.

Presence. An adapted 22 item presence questionnaire (Witmer et al., 2005), excluding touch was used rated on a seven-point scale across six factors: possibility to act, possibility to examine, realism, quality of interface, sounds and self-evaluation of performance. Scores were calculated per the questionnaire’s guidance

Acceptability, tolerability, face validity and fidelity of the task. Open and closed questions (adapted from Chertoff et al., 2010 and Höner et al., 2023) were asked to all participants. Sample questions included: ‘How well did you feel you were able to move your head?’ (see Table 1).

Table 1

Follow up questions asked to participants after completing the 360-video soccer task

Question/Measure	Category
How well did you feel you were able to move your head?	Physical Fidelity
How involved did you feel in the match situation?	Face Validity
Did the task lead you to experience any feelings of nausea or sickness?	Tolerability
How much did the 360-video trials look like real-life football?	Face Validity
Would you use this 360-video simulation again?	Acceptability
How often would you use this 360-video simulation? Please respond in number of times per week: 0, 1-2, 3-4, 5-6 or 7.	Acceptability
How much did the 360-video feel like real life football?	Face Validity
What would you use the 360-video footage for?	Acceptability
Is there anything that you think would prevent you from using 360-videoin football?	Tolerability
What would be important to a good football training session using 360-video?	Acceptability

Data Analysis

Reliability

A senior lecturer in sport psychology with prior VEA coding experience conducted additional coding on all variables to assess inter-rater reliability. A total of 132 trials (15% of all trials), were re-analysed for inter and intra-rater reliability aligning with previous VEA research (Aksum, Pokolm et al., 2021; Feist et al., 2024). Intra-rater reliability was tested following a six-week gap to minimise potential learning effects. Intra-class correlations (ICC) were calculated for the continuous variable ‘number of scans’, the basis for scan frequency and were assessed following Cicchetti (1994) criteria to determine the strength of agreement between different coders and repeated coder observations (see Table 2).

Table 2

Intra-class correlations for number of scans (continuous variable)

	Inter-rater		Intra-rater	
Variable	ICC (95% CI)	Strength of Agreement	ICC (95% CI)	Strength of Agreement
Number of scans	0.902 (0.865-0.930)	Excellent	0.953 (0.934-0.966)	Excellent

Statistical Analysis

Normality was assessed using the Shapiro-Wilk test, histograms, boxplots, and zskewness/zkurtosis with ±1.96 criteria applied (O’Donoghue, 2013). Between-group comparisons of questionnaire items used independent samples t-tests for normal data and Mann-Whitney U tests for non-normal data. Levene’s test confirmed equal variances ($p > 0.05$). Mann-Whitney U tests compared scan frequency, actions per trial and action details per trail between groups, with medians and interquartile ranges reported. A two-way mixed ANOVA examined scan timing differences in the final five seconds before ball contact. A 2 Group (soccer players, novices) x 6 verbal action response category (pass, shot, dribble, receive and protect the ball, turn with the ball and unsure) ANOVA with Greenhouse-Geisser correction was performed for action type and action detail, with the assumption of sphericity being violated for both tests. Verbal action response categories were treated as repeated measures, similar to that of Roca et al. (2011). Bonferroni-adjusted t-tests were used to determine the source of the effect. Effect sizes for ANOVAs (partial eta squared) were small (≈.01), medium (≈.06), large (≈.14) (Cohen, 1988) and for t-tests (Cohen’s *d*): small (0.20–0.49), medium (0.50–0.79), large (≥0.80) (Cohen, 1992). Rank Biserial-Correlation (range: -1 to +1) provided further measures of effect size. The alpha level was $\alpha = 0.05$, and analyses were conducted in JASP (version 0.16.4).

Results

All participants reported good levels of presence (for presence questionnaire data, see supplementary material).

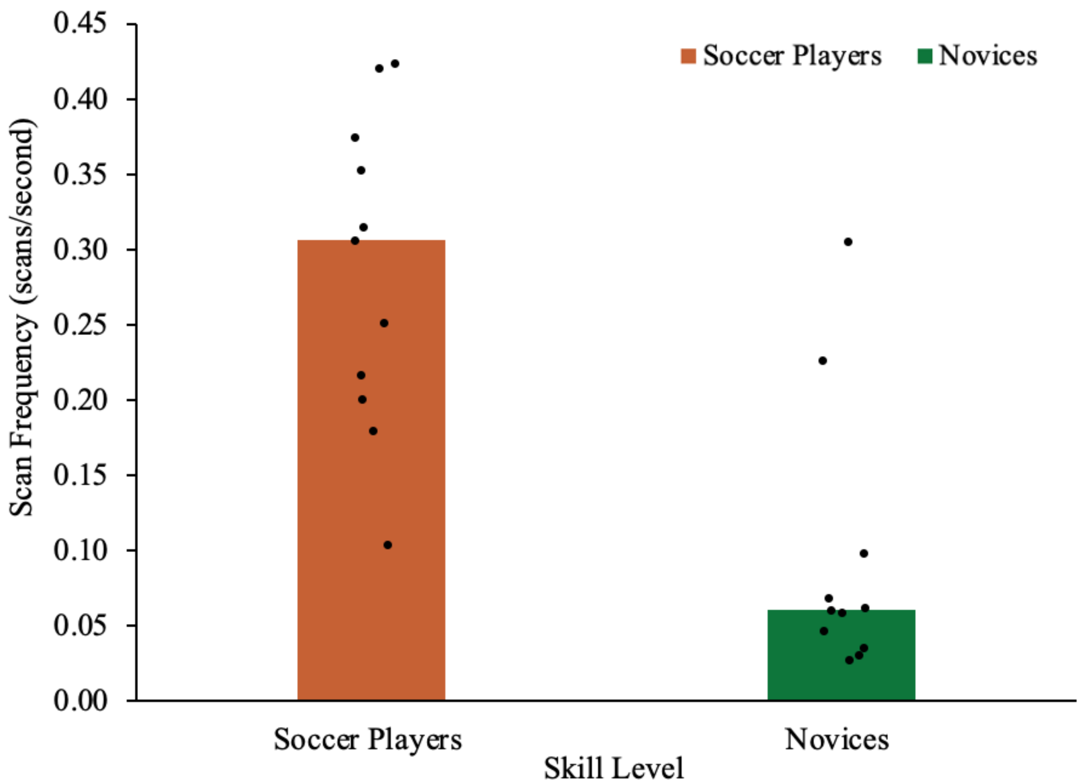
Construct Validity

Scan Frequency

Soccer players performed significantly higher scan frequencies (*Mdn* = 0.31 scans/s, IQR = 0.155) compared with novices (*Mdn* = 0.06 scans/s, IQR = 0.040; $U = 10.50$, $p < 0.001$, rb = -0.83; Figure 3).

Figure 3

Scatter bar displaying median scan frequency (scans/s) between soccer players and novices. Bars represent median scan frequency scores by skill level. Black dots represent individual data by participant

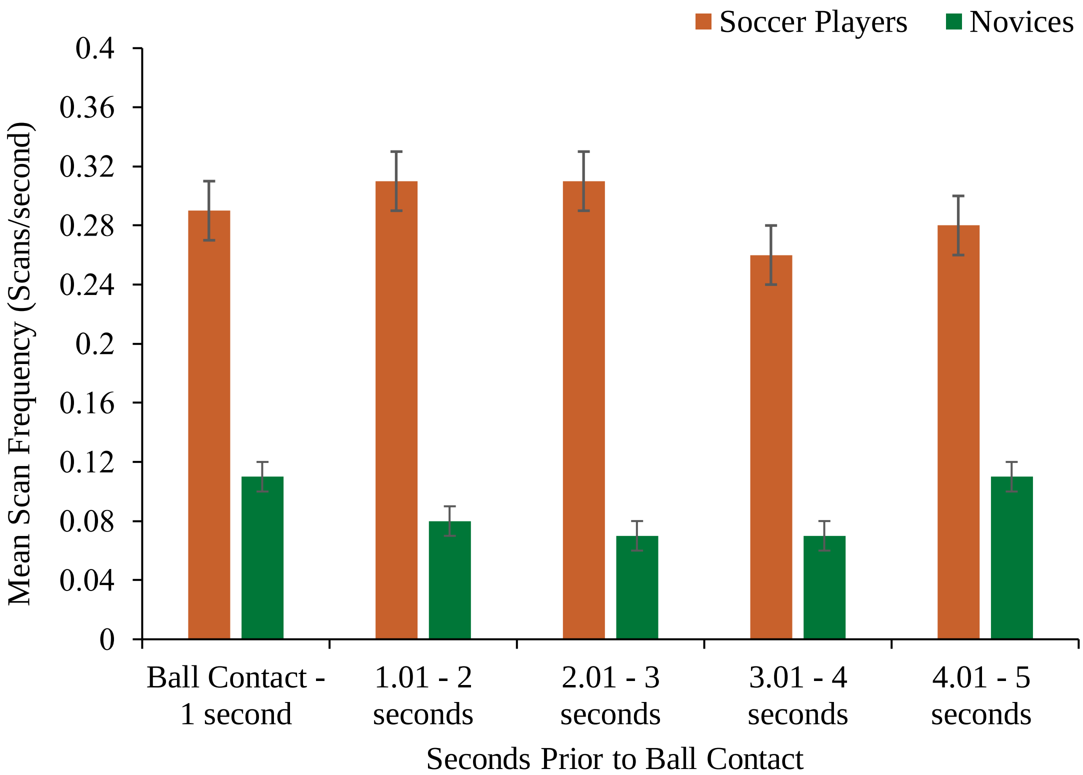


Scan Timing

For soccer players, the highest mean scan frequency was observed between 1.01 - 3 seconds and for novices was between ball contact - 1 second and between 4.01 - 5 seconds prior to receiving a pass from a teammate (see Figure 4). A significant main effect of skill level on scan timing, $F_{(1, 20)} = 16.68$, $p < 0.001$, $\eta^2 = 0.364$ was found with soccer players scanning significantly more often than novices. There was no significant main effect of time, $F_{(4, 80)} = 0.55$, $p = 0.703$, $\eta^2 = 0.005$, and no significant interaction between scan timing and skill level, $F_{(4, 80)} = 0.74$, $p = 0.565$, $\eta^2 = 0.007$.

Figure 4

Means and Standard Errors (presented as error bars) across the final five seconds prior to receiving the ball for soccer players and novices



Verbal action responses

Number of actions and number of action details generated per trial

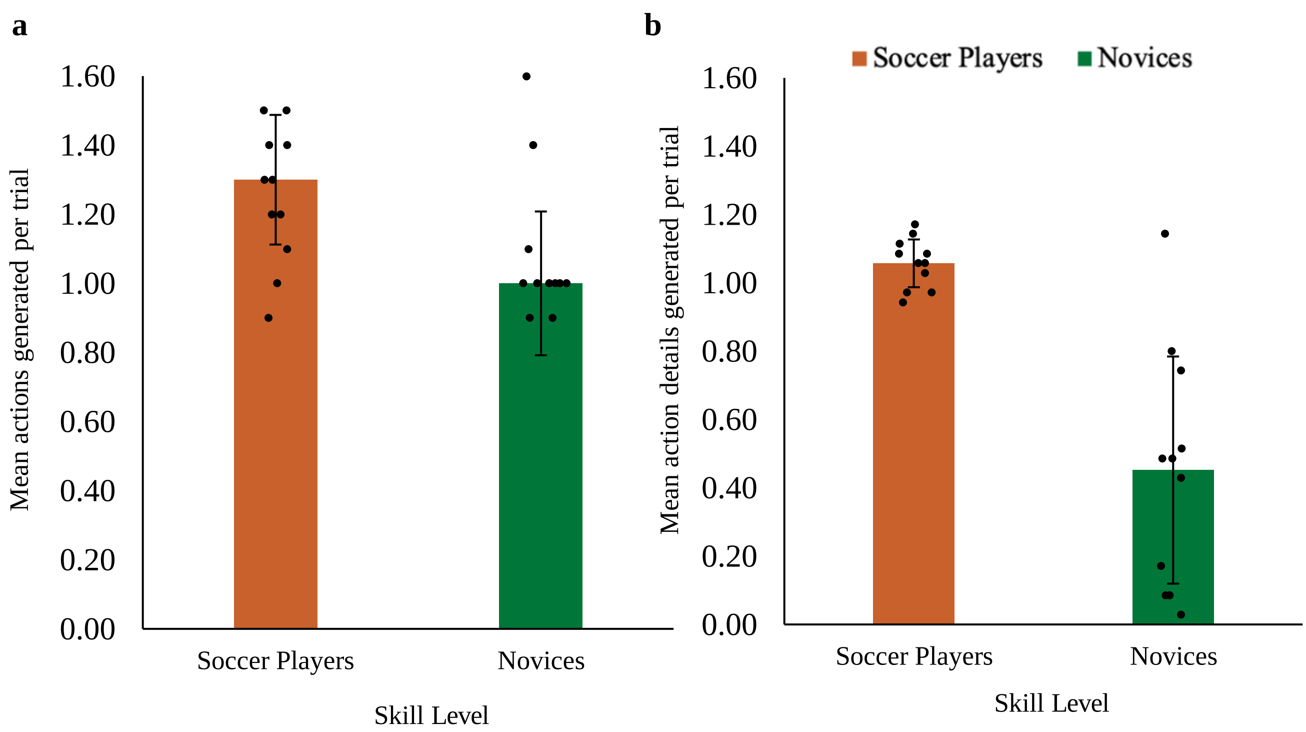
Soccer players generated significantly more actions per trial (*Mdn* = 1.30, IQR = 0.25) compared to novices (*Mdn* = 1.00, IQR = 0.05, $U = 31.50$, $p = 0.028$). Soccer players also generated more action details per trial ($M = 1.06$, SD = 0.07) compared to novices ($M = 0.45$, SD = 0.35, $t_{10.899} = 5.653$, $p < 0.001$, $d = 2.410$). The number of actions and number of action details generated per trial data is presented in Figure 5.

Action Type

Results indicated a significant main effect of verbal action response category, $F_{(2.37, 47.37)} = 69.09$, $p < 0.001$, $\eta^2 = 0.755$. Bonferroni-corrected follow up test comparisons demonstrated that participants verbalised the action of pass significantly more than all other action categories ($p < 0.001$). There was no significant main effect of skill level, $F_{(1, 20)} = 3.30$, $p = 0.084$, $\eta^2 = 0.003$, and no significant interaction between verbal action response category and skill level, $F_{(2.37, 47.37)} = 0.49$, $p = 0.648$, $\eta^2 = 0.005$.

Figure 5

Scatter bars displaying mean number of verbal action responses (a) and the mean number of verbal action response details per trial (b) between soccer players and novices



Action Detail

There was a significant main effect of verbal action response detail category, $F_{(2.30, 46.09)} = 24.26$, $p < 0.001$, $\eta^2 = 0.450$. Follow up test comparisons demonstrated that participants verbalised the action detail of pass significantly more than any other action categories. There was a significant main effect of skill level, $F_{(1, 20)} = 28.25$, $p < 0.001$, $\eta^2 = 0.050$ with soccer players verbalising significantly more action details compared to novices. A significant interaction between verbal action response detail category and skill level, $F_{(2.30, 46.09)} = 0.49$, $p = 0.008$, $\eta^2 = 0.093$ was found.. Table 3 contains soccer players' and novices verbal action detail.

Table 3

Descriptive analysis of soccer players' action response verbalisations

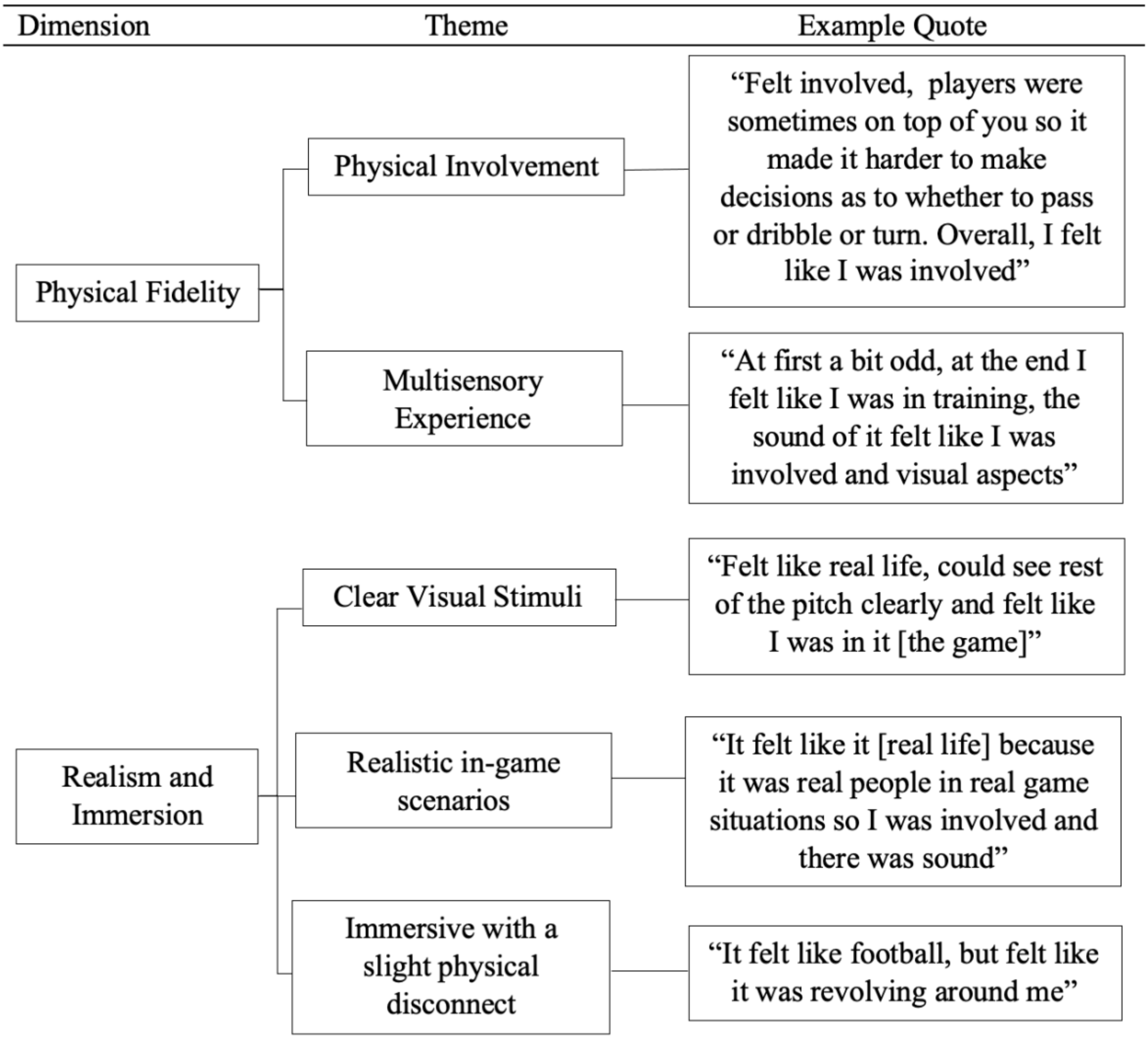
	Frequency		Action Detail	
Action Type	Soccer Players	Novices	Soccer Players	Novices
Pass	257	227	228	86
Shot	52	57	3	2
Dribble	118	91	104	45
Receive and protect the ball	13	11	9	2
Turn with the ball	46	37	63	48
Unsure	0	2	0	0
Total	486	425	407	183

Face Validity & Fidelity

All soccer players commented on how they were able to move their head freely when wearing the Meta Quest 2 with two players stating that it took them a short amount of time to adjust to wearing a headset. Soccer players shared how the soccer video task felt and looked like real-life soccer with clear visuals of players on the pitch and match realistic sounds. Thematic analysis capturing participants responses can be found in Figure 6.

Figure 6

Dimensions and Themes that emerged from questions on soccer players perceptions of face validity and physical fidelity of the 360-video soccer simulation task

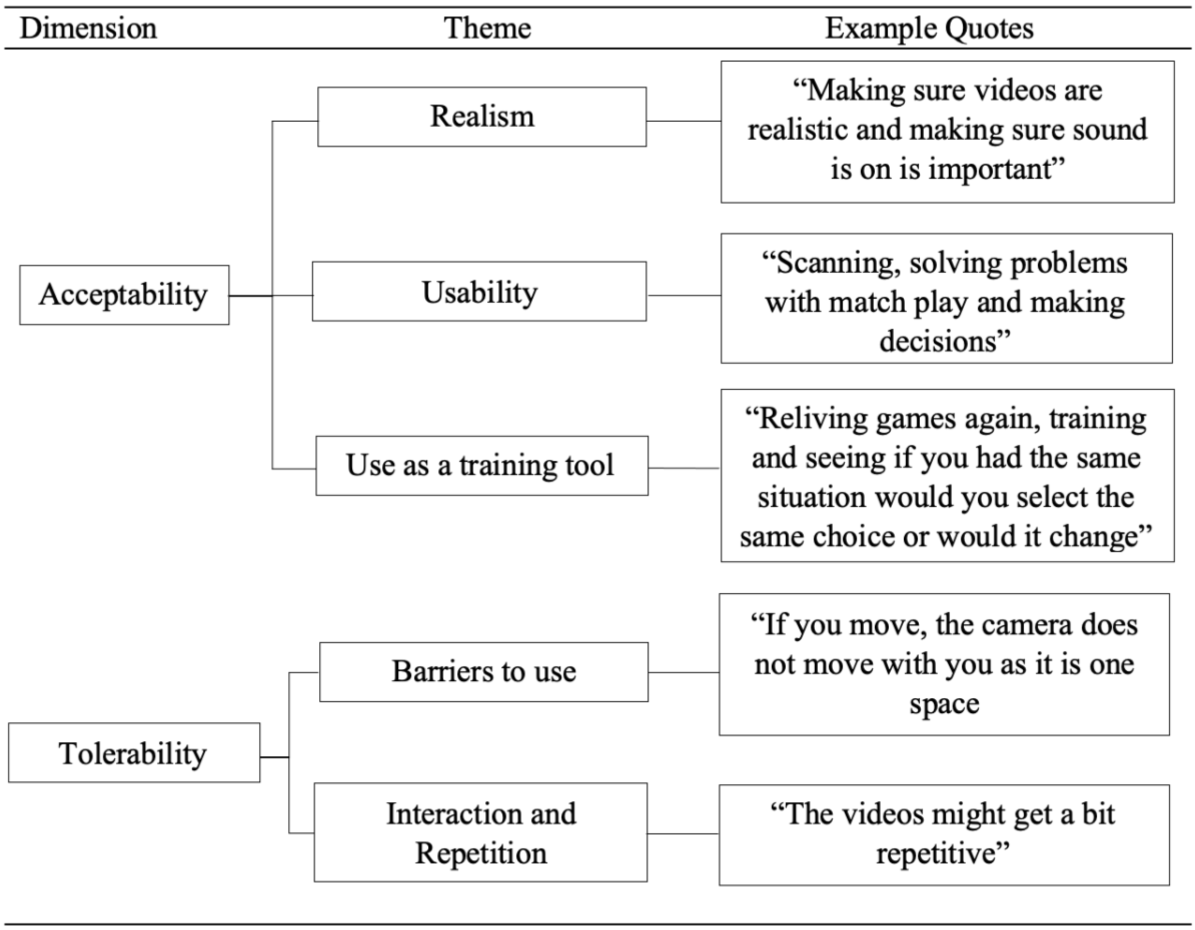


Acceptability & Tolerability

No participants reported motion sickness from the 360-video soccer video stimuli. All soccer players reported that they would be interested in using 360-video in training and testing. When asked how often players would use 360-video, responses ranged from one per month to one-to-two times per week. Nine soccer players explicitly shared the importance of using match-realistic scenarios which could be evaluated with a coach as part of team-based video analysis. Thematic analysis capturing participants responses can be found in Figure 7.

Figure 7

Dimensions and Themes that emerged from questions on soccer players acceptability and tolerability of the 360-video soccer simulation task



Discussion

The study aimed to assess the construct and face validity of a 360-video simulation for capturing VEA in women’s soccer and to understand perceptions of acceptability and tolerability of the task. Results indicated the newly developed 360-video soccer task demonstrates construct and face validity. Soccer players exhibited significantly higher scan frequencies and generated significantly more verbal actions with the ball per trial compared to novices, supporting construct validity. No significant differences were reported across any of the presence questionnaire items, with all participants reporting moderate to high presence in the environment. Overall, the 360-video task indicated construct and face validity was achieved, with good acceptability, tolerability and physical fidelity.

As hypothesised, sub-elite soccer players displayed significantly higher median scan frequencies compared to novices. This suggests players actively scanned their environment for critical information to inform actions upon receiving the ball (Aksum, Pokolm et al., 2021). Studies in men’s soccer link higher scan frequencies to improved performance with the ball and expertise (McGuckian et al., 2018). In the current study, soccer players highest scan frequencies were between 1.01 – 3 seconds compared to novices' highest scan frequencies between ball-contact – 1 second and 4.01 – 5 seconds. Once the trials started, novices tended to 'ball watch' and would typically only scan their environment as the ball approached, suggesting that novices' scanning was more reactive, compared to soccer players. These findings demonstrate minor differences in scan timing between the two skill level groups, with soccer players scanning significantly more than novices. Lastly, soccer players generated more action responses per trial and more action details compared to novices. One possible explanation for this is that by scanning their environment more frequently, soccer players were able to generate richer responses on subsequent actions with the ball compared to novices. These findings align with previous research where skilled athletes produced more task-relevant options and detailed verbal responses compared to novices (Murphy et al., 2019; Roca et al., 2011). Therefore, this 360-video task appears representative of real-life soccer by its ability to distinguish between soccer players and novices across measures of VEA and verbal action responses and so may be a valuable tool in assessing VEA in women soccer.

Both soccer players and novices reported good levels of presence where participants scored highest for levels of realism and lower for possibility to act. This evidence suggests soccer players perceive the 360-video environment as somewhat immersive indicating its potential as a suitable tool for assessing players' VEA in match-realistic situations. To understand soccer players perceptions of face validity and physical fidelity open-ended questions were asked to all soccer players. Seven of the eleven soccer players stated they could move their heads and scan their environment freely with the Meta Quest 2 headset, feeling immersed in the match situation suggesting good physical fidelity. This will likely continue to be improved with newer, lighter headsets. Previous research on 360-video's effectiveness in enhancing decision-making skills among Australian football umpires found athletes reported greater task engagement compared with viewing traditional broadcast footage (Kittel, Larkin, Elsworthy et al., 2020), supporting the immersive feel of 360-video. However, players described limitations such as the ball not being at their feet in the testing room and the inability to move within the 360-video environment. Research highlights primary limitations of 360-video including restricted perception-action loop (i.e. action fidelity) and reliance on stationary footage (Kittel, Larkin, Cunningham et al., 2020). Thus, future research should explore mixed reality benefits which may facilitate perception-action links (Kittel et al., 2021). Overall, feedback indicates soccer players perceive the simulation as immersive, suggesting a moderate to high level of presence and face validity.

Following guidelines for developing simulated environments (Birckhead et al., 2019), the study assessed participants perceptions of acceptability and tolerability of the task. All soccer players reported no motion sickness and all soccer players expressed interest in using 360-video for training and testing purposes. Soccer players frequently mentioned 360-video as a tool to support physical and team-based training suggesting it could be used 1-2 times per week. Previous research found 91% of male soccer players viewed 360-video as a potential training tool (Musculus et al., 2021), with further research reporting soccer players demonstrated positive ratings for motivational effect, acceptability and immersion in a 360-video for decision making (Höner et al., 2023). This evidence suggests 360-video may aid in understanding perceptual-cognitive skills in soccer with both men's and women's players indicating high willingness to use the simulation for training and testing. Soccer players suggested cost, lack of in-game movement and time availability as potential barriers to 360-video use. Despite players perceiving 360-video to be high in cost, research suggests that developing 360-video stimuli and importing this into a HMD is a lower cost option compared to creating custom VR software (Kittel, Larkin, Cunningham et al., 2020; Barbour et al., 2024). To summarise, no participants reported motion sickness indicating good tolerability and although soccer players shared potential barriers to the use of 360-video, players also emphasised its value to develop perceptual-cognitive skills. With players expressing a willingness to use 360-video again, the task appears to demonstrate good acceptability and tolerability.

Study Limitations & Future Research Directions

A limitation of current study is that the soccer players recruited were sub-elite rather than elite. As a result, caution is warranted when generalising the findings to more elite populations. Future research should aim to investigate VEA using 360-video with a more elite cohort of players to better enhance the applicability and transferability of the technology for measuring VEA. Furthermore, consistent with previous literature, asking participants to verbalise their actions and act out soccer specific movements may not have captured their full capabilities (Panchuk et al., 2018; Dicks et al., 2010). While the task distinguished between soccer players and novices in scan frequency and the number of actions generated per trial, with evidence of face validity and immersion, future research is still necessary to further validate this simulation. This study provides initial evidence that 360-video may be a useful tool for testing VEA in women's soccer, however additional research is still needed to examine other forms of fidelity, such as psychological and biomechanical fidelity to understand whether there is any opportunity for training and transfer of learning to soccer performance (Harris et al., 2020). This presents an opportunity to use 360-video to simulate match-realistic game situations and conduct further experimental research in women's soccer.

Practical Implications

Based on the study's findings, we propose some practical implications. Practitioners should consider using first-person game footage as an individualised tool, incorporating additional contextual and perceptual factors to challenge soccer players. Our results suggest soccer players view 360-video as a beneficial addition to physical team-based training. With 360-video enabling multiple repetitions of in-game scenarios without injury or fatigue risks (Musculus et al., 2021), this technology could also support rehabilitation for players returning to play from injury (Musculus et al., 2021) or illness.

Conclusion

This study assessed the construct and face validity of a 360-video simulation for capturing VEA in women's soccer and to understand players' perceptions of acceptability and tolerability of the task. Following Harris et al. (2020) and Birckhead et al. (2019) guidelines, we used an evidence-based approach to test the validity of a 360-video soccer simulation. Results demonstrated construct validity with significant differences in scan frequency and the number of actions generated per trial between soccer players and novices. Soccer players had significantly higher scan frequencies and generated significantly more verbal action responses per trial compared to novices. Participants rated the task highly for acceptability, tolerability and physical fidelity, with soccer players sharing expressing immersion in the task. These findings offer preliminary evidence that this 360-video task may be sufficiently representative of soccer for visually examining the environment suggesting it could serve an alternative to traditional video-based methods in understanding how female soccer players visually explore their environment. Future research should now further validate the use of 360-video as a tool for training and testing in women's soccer.

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