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Original research

Cricketers are not tickled pink by the new coloured ball

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ABSTRACT

Objectives: Cricket administrators have started scheduling long-form matches which finish at night and are played with a pink as opposed to a red ball. However, there are reports that the pink ball may introduce new dangers and alter performance. The aim of this study was to investigate professional cricketers' opinions about the visibility of the pink ball whilst playing in different lighting conditions (afternoon, dusk and night).
Design: Purposeful sampling of a cross-section of elite cricketers with pink ball experiences playing in the United Kingdom.
Methods: Eighty-eight international or first-class professional cricketers completed a questionnaire consisting of Likert scale and free text responses to questions covering perceptions of the pink ball, with a particular emphasis on visibility.
Results: The pink ball was reported as less visible than the red ball when batting ($p < 0.001$) and fielding ($p < 0.001$). Within the three lighting conditions the pink ball was significantly less visible at dusk under floodlights compared to afternoon and night both when batting and fielding (ps < 0.001). Free text comments confirmed that visibility of the pink cricket ball was most challenging at dusk (coverage 0.37), and that players sometimes experienced a blurring sensation with the pink ball leaving a visual 'trail' when viewed under floodlights (coverage 0.24).
Conclusions: Results advocate that governing bodies should consider the inclusion of a break in play during dusk to enhance player safety and performance. Empirical research is needed to quantify the risks to player safety in different lighting conditions.

Practical implications

- This systematic investigation of professional cricketers' opinions suggests that the pink ball is more difficult to see than a red ball both when batting and fielding.
- The results of this study suggest that visibility is poorest at dusk and therefore that player safety may be most compromised with the pink ball during that period.
- Experience playing and/or practicing with the pink ball does not affect perceived visibility, suggesting the difficulties are related to environmental conditions such as lighting, dusk duration, atmospheric conditions and geographical location.
- The results provide justification for administrators to avoid play at dusk, suggesting that breaks should be scheduled during this period to enhance player (and umpire) safety.

1. Introduction

Test cricket has traditionally been played during daylight hours using a red ball.[1] A decline in the number of spectators attending international Test matches, and the opportunity to broadcast

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matches at night in some countries, led in 2015 to the commencement of Test matches starting in the afternoon and progressing through dusk into the evening under artificial lighting (i.e., a day–night match).[2] As the game progresses into the evening and the sun begins setting, there is a disproportionate scattering of higher frequency wavelengths of light that results in the sky having a reddish hue.[3] This alteration in the composition of light changes the luminance contrast of red cricket balls, making them challenging to see under the potentially reddish (at dusk) and then black (at night) sky encountered during a day–night match.[4] Players in Test cricket are taken from the field of play when light conditions deteriorate to a level that the umpire adjudicates that it is not safe to continue play. Accordingly, a different coloured ball was necessary for matches to be played at night.

A white ball has been successfully used in the shorter formats of cricket; however, a white ball is an unsatisfactory solution for Test matches or other longer forms of the game (e.g., 4-day matches). White cricket balls offer a reasonably high level of contrast at dusk, and at night, when players wear coloured clothing and black sight screens are located behind the bowler's hand. However, a major limitation of the white ball for Test cricket is that the rules stipulate that a ball must be used for at least 80 overs without change, yet the white ball is known to discolour after about thirty overs. One-day cricket addresses this problem by using two different balls within a single innings, but this is not an acceptable solution for Test cricket.[5] Therefore, an alternative colour that could be used for at least 80 overs was required.

Cricket ball manufacturers have developed a variety of coloured balls that include fluorescent yellow, orange and pink colours[6] to increase the visibility of the ball at dusk and at night. Orange balls ceased to be used following criticism that the ball was difficult for television cameras to pick up, and the yellow ball was discarded because it left a "*streaking effect*" on television screens, i.e., the ball appeared to have a tail.[7] A *pink cricket ball* was chosen for use and introduced into international Test cricket following approval from the International Cricket Council (ICC).

Despite the growing popularity of day–night Test matches that use a pink cricket ball, some players have expressed reservations about the visibility of the ball, leading to concerns about player performance and safety.[8] Moreover, anecdotal reports suggest that players, in particular those with colour-vision deficiencies, have been forced to withdraw from matches where a pink ball was used because they find the ball particularly difficult to see.[9] Acquiring visual information when batting and fielding is vital,[10] with success when batting relying on acquiring early ball-flight information,[11,12] and information available from the bowler's movement kinematics (e.g., angle of the upper body) prior to ball-release.[12,13] Successful fielding often relies on information from the batter's posture prior to bat-ball contact.[14] Although high levels of visual acuity may not necessarily be vital for optimum information pick-up[15,16] good contrast presumably is.[17] In support, a recent study investigating the visibility of the pink ball in cricket concluded that visibility is impacted, particularly at dusk, because of the ball's very low luminance contrast when compared to the sky.[4] In particular, it was suggested that the ability to perceive motion would be most notably impacted. Colour vision deficiencies may further alter the luminance contrast, exacerbating the difficulties experienced when hitting and fielding.

Despite the concerns about the pink cricket ball, and anecdotal reports about player dissatisfaction, players are still required to play at dusk, and night, in playing conditions that might be more difficult or indeed dangerous to player safety. Given the growing popularity of day–night Test matches, and the potential threat to the livelihood of players who cannot or will not play in matches using a pink ball, we sought to systematically investigate player perceptions about playing in different lighting conditions during day–night matches. Therefore, the aim of this study was to investigate professional cricketers' opinions about the visibility of a pink cricket ball whilst playing in day–night matches. The results were expected to be of interest to key stakeholders involved in the continued development of day/night cricket whilst optimising player performance and safety.

2. Methods

Currently, there are no standardised measures available to evaluate experience with the pink cricket ball. Therefore, a cross-sectional survey was developed in collaboration with the research team and an advisory group of sports researchers, elite cricketers, and cricket administrators. Two researchers (PA, LW) initially developed a 35-item questionnaire adopting the principles from the *Collegiate student-athletes' satisfaction with athletic trainers survey*.[18] Then in an iterative process the research team refined it to a 33-item questionnaire. The advisory group (sports researchers, elite cricketers and cricket administrators) then reviewed the questionnaire to ensure face validity and interpretability. Minor modifications were made to the questionnaire before it was sent to two elite cricketers to determine whether the questions were clear and easy to answer. They confirmed that the length of the questionnaire was suitable and that they experienced no difficulties with the format or comprehensibility of the questions. Further alterations were made to the questionnaire wording following ethical review from the Faculty Research Ethics Panel of Anglia Ruskin University (1118–01).

The final questionnaire consisted of four sections (see below) and took between 15–20 min to complete. Section A about *Player Characteristics* contained questions requiring self-disclosure of any vision problems, a personal rating of vision quality, and information about playing experience in matches and/or training with a pink cricket ball. Section B evaluated *visibility of the pink ball under different lighting conditions (when compared to the baseline Test-match condition of playing with a red ball during regular daylight conditions)*, with participants asked to rate on a 15-point Likert scale the visibility of the pink cricket ball while batting and fielding. Negative values (down to -7) indicated better visibility with the pink ball, while positive values (up to +7) indicated better visibility with the red ball. Zero indicated no difference between the visibility of the pink and red ball. Section C evaluated *adaptions to playing style with the pink ball*, again using 15-point Likert scales. Players were asked to compare the visibility of the pink ball when batting against pace and spin bowling. Negative values (down to −7) indicated pace bowling was more difficult, while positive values (up to +7) indicated spin bowling was more difficult to face. Zero indicated no difference between facing pace and spin bowling. Players were then asked to rate the visibility of different delivery types (e.g., 'bouncer', 'yorker', 'slower' and 'normal' deliveries) when batting at night under floodlights compared with the red ball under daylight conditions. Negative values (down to -7) indicated better visibility with the pink ball, while positive values (up to +7) indicated better visibility with the red ball. Zero indicated no difference in visibility. Participants were asked (yes/no) whether the pink ball had resulted in a change to either their batting or fielding styles. Moreover, opinions were sought regarding the future direction of pink ball cricket, including opinions about the use of an alternative colour ball, coloured clothing, and coloured sight screens. In Section D, we sought to evaluate the *overall acceptance of the pink ball*, with participants asked (yes/no) whether they enjoyed playing in pink ball matches and whether the pink ball adds value to the wider game of Test cricket (see Appendix A1 for the full questionnaire).

Purposeful sampling was used to recruit participants (international and first-class male cricketers) from counties in England and

Wales likely to have had experience playing and/or training with the pink cricket ball at the end of the 2018 English county cricket season. The questionnaire was available to cricketers throughout September 2018. The data were collected using a paper questionnaire distributed and collected via the Professional Cricketers Association's Professional Development Managers.

Quantitative data were analysed using Statistical Package for Social Sciences (SPSS) version 26.0 (IBM Corp, 2019). Likert-scale responses were treated as non-parametric ordinal data and summarised using the median. A one-sample Wilcoxon signed-rank test was used to determine whether values differed to zero. The Friedman test was used to investigate whether significant differences existed between conditions. Where appropriate, follow up post-hoc testing was performed using a paired-sample Wilcoxon signed-rank test with Bonferroni corrected p values (revised p-value of 0.025).

Free text responses were analysed using an inductive content analysis approach to produce themes that could be used for categories in a subsequent content analysis.[19] Participant responses were broken into clauses, and each clause was coded based on the themes generated. The themes generated were: *(i) lighting conditions; (ii) ball quality; (iii) difficulties tracking the ball; (iv) adaptations to playing style; (iv) factors not worth changing; (v) residual effects; (vi) ball speed, and (vii) factors that did not change.* This process was conducted for each question, with multiple codes allowed per participant per question, for example a participant might have highlighted both the lighting conditions and ball quality when answering a question about difficulties when facing fast bowling. Once coding was complete, similar codes were grouped into themes and the coverage of that theme (the frequency with which the codes associated with that theme appeared in the free text comments) was calculated, with a maximum possible coverage of 1.0 (all free text comments were grouped within this one theme). Themes with low coverage (less than 0.10) were not reported. To ensure inter-rater reliability and reduce bias,[20] the data were coded by the lead researcher and separately by an independent researcher. A Cohen's K was run to determine the level of agreement between researchers. There was a high level of agreement between researchers ($k = 0.714$, $p < 0.001$).

3. Results

Of the 88 participants who responded, the data from two participants were discarded as they had no experience playing or training with a pink cricket ball. Players who had experience training with but not playing with the pink cricket ball (or vice versa) were included in the study. The ages of the remaining 86 participants ranged from 19 to 38 years, with a mean of 27.7 ± 4.9 yrs. The number of pink ball matches ranged from 0 to 10 matches with a mean of 2.4 ± 1.1 matches. The number of training sessions with the pink ball ranged from 0 to 8 sessions with a mean of 2.2 ± 1.8 training sessions. When asked to rate their vision on a scale from 1 (very poor) to 10 (excellent), a mean rating of 8.7 (± 1.5) was recorded. A colour vision deficiency was reported by 3 participants.

Internal consistency for the Likert questions was high (Cronbach's alpha of 0.81). In Section B we evaluated the visibility of the pink cricket ball when compared to our baseline condition viewing the red cricket ball during daylight. Median values of the visibility of the pink ball compared to baseline conditions of the red ball during daylight (Section B of the survey) indicated that participants rated the pink cricket ball as being less visible during batting, when compared to the red ball, irrespective of the lighting conditions in which the pink cricket ball was viewed (Fig. 1A). A one-sample Wilcoxon signed-rank test indicated that the self-reported value aggregated across all conditions (median = +2) was significantly different from 0 ($z = 5.39$, $p < 0.001$), with the pink ball rated as being less visible than the red ball. However, there was a significant difference in the visibility scores across all three lighting conditions ($\chi^2(2) = 26.82$, $p < 0.001$). Post-hoc testing highlighted that that visibility of the pink ball was significantly worse when batting at dusk (median = +3) than when batting in the afternoon under natural light (median = +1, $z = -3.52$, $p < 0.001$). There was no significant difference between the visibility of the pink ball when batting at dusk and at night.

The pink cricket ball was also rated as being less visible irrespective of the lighting conditions while fielding (Fig. 1B). The self-reported rating aggregated across all conditions during fielding (median = +2) was significantly different from 0 ($z = 5.69$, $p < 0.001$), with the pink ball significantly less visible than the red ball. Again, there was a significant difference in the visibility of the pink ball depending on the lighting conditions ($\chi^2(2) = 27.51$, $p < 0.001$). Post-hoc testing showed the pink ball to be rated as significantly less visible when fielding at dusk (median = +3) than it was when fielding in the afternoon under natural light (median = +1; $z = -3.805$, $p < 0.001$). There was no significant difference between the visibility of the pink ball when fielding at dusk and at night ($p = 0.033$, Bonferroni corrected).

Content analysis of the free text comments ($n = 41$) about the visibility of the pink compared to the red ball highlighted two key themes for both batting and fielding: (1) lighting conditions (coverage 0.37); and (2) residual colour effects (coverage 0.24). The theme of lighting condition revealed dusk (under floodlights) to be the most challenging condition in which to view the pink ball. Example responses included:

> "Only seems to be a problem at dusk", "Twilight is toughest", "Dusk is hardest part", and "Batting to start with in dusk is slightly harder"

The residual colour side effects described specific visual sensations experienced with the pink ball when used under floodlights. Example responses included:

> "Ball traces under lights", "Ball seemed a bit of a blur", "Ball isn't clear, almost seems a bit of a blur", "leaves a trail", and "flash of pink sensation when facing pace"

A player's level of experience with the pink ball did not alter their rating of its visibility either when batting ($u = 784$, $p = .53$) or fielding ($u = 694.5$, $p = 0.08$) under the most visually demanding conditions (i.e., at dusk under floodlights when compared to daytime in natural light).

In Section C, the pink ball was rated as being significantly less visible when batting against pace compared to spin bowling (median value = −2; $z = -4.09$, $p < 0.001$). When asked to expand on their Likert responses, the main theme from the open-ended responses related to difficulties facing faster-paced bowling (coverage of 0.39), with the visibility of the pink cricket ball reported to be more difficult when facing faster delivery speeds.

When considering only faster bowling, there was no significant difference in the ratings of visibility against different delivery types (i.e., bouncers, yorkers, slower, and normal deliveries) when facing the pink ball under floodlights ($\chi^2(2) = 7.781$, $p = 0.05$). Although not significant, the borderline nature of the p-value suggested that post-hoc testing was warranted. The post-hoc testing showed the pink ball to be significantly less visible when facing short-pitched deliveries (bouncers, median = +2) when compared to slower deliveries (median = 0; $z = -2.651$, $p = 0.008$). Example free-text responses included:

> "Harder to see pink ball seam, particularly at dusk", "Faster ball makes pink ball harder to pick it up", and "Harder to track pink ball."

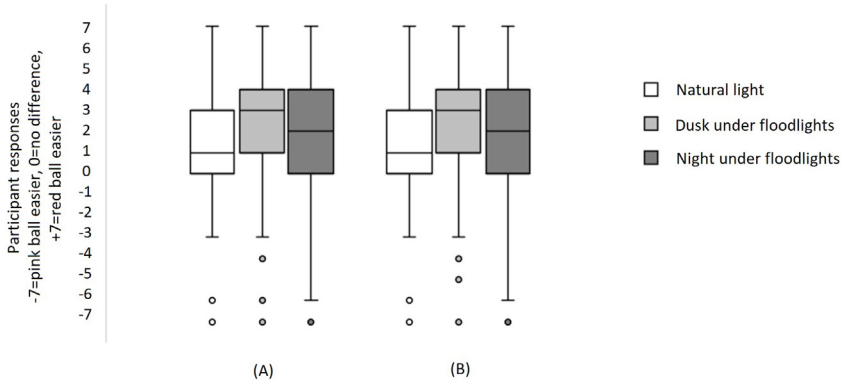

Fig. 1. Participant ratings of visibility of the pink ball, when compared to the red ball in natural daylight, in three different light conditions during (A) batting and (B) fielding. The solid line within each boxplot represents the median response and circles represent outliers.

Participants were asked whether they felt that any difficulties in seeing the pink cricket ball (if experienced) was temporary or permanent. Fifty eight percent of participants suggested that the difficulty was temporary. Free text responses revealed the only prominent theme to be the ability to adapt to conditions (coverage of 0.53). Example responses included:

> "Better as it gets darker", "I tend to get used to it after about 3 overs", and "Takes getting used to, especially with varying backgrounds"

When asked whether they had to change their batting or fielding style in order to accommodate the pink cricket ball, 92% of participants ($n = 80$) reported no change in their batting style, and 91% ($n = 79$) reported no change in their fielding style. Only a relatively small proportion of participants elaborated on their answer to this question ($n = 25$). The main theme from the responses related to difficulties in tracking the ball (coverage 0.32). Responses included:

> "I wear sunglasses to dim the glare off a pink ball, particularly a new pink ball", "You have to watch the ball much harder and closer", and "During twilight under the floodlights, tried to stay down longer"

Free text comments also suggest that players answering yes feel the need to change fundamental aspects to their game. In particular, responses say:

> "I am more aggressive as the pink ball under lights does so much", or "During twilight, tried to stay down longer"

When asked if they thought that a different coloured ball other than red would be preferable to the pink ball, 75% of participants responded "no". Thirty-seven percent of respondents agreed that the use of coloured clothing (in conjunction with a white ball) would be preferable to using a pink ball, and 34% of respondents agreed that using a different coloured sightscreen would aid visibility of the pink ball.

In Section D, 80 participants responded to open-ended questions about their individual acceptance of the pink ball. Only 47.5% of participants ($n = 38$) reported that they enjoyed playing pink ball cricket and 52.5% of participants ($n = 42$) reported that they did not enjoy pink ball cricket. Analysis of the free text responses highlighted two key themes: positive personal challenge (coverage 0.30), and ball quality issues (coverage 0.17). Responses included:

> "It's something different, a new challenge", "Different, an exciting change", "difficult to keep the ball in good condition", and "ball went soft and was impossible to shine"

Finally, 54% of participants ($n = 43$) responded that the pink ball *was* positive for the game, and 43% ($n = 34$) responding that it was *not* positive for the game. The two main themes involved the impact of match start times on crowd attendance (coverage 0.31), and weather dependency (coverage 0.17). Responses included:

> "It allows crowds to watch the game later", "new, bigger crowds watch, better atmosphere", and "Abroad is good but not dark enough here. Too much difference in conditions when lights are on", "Not in this country. It is both too cold (usually) and not dark enough for long enough"

Responses throughout the survey from the three participants identified as having a colour-vision deficiency highlighted difficulties with the visibility of the pink ball whilst batting (median = +5), and fielding (median = +4) at dusk under floodlights, and when batting (median = +5), and fielding (median = +6) at night under floodlights. These high median scores suggest that this group may experience greater difficulty viewing the pink cricket ball when compared to the remainder of the playing group.

4. Discussion

The introduction of the pink ball into Test cricket has been controversial, with several high-profile players expressing their dissatisfaction with its use, and some players even withdrawing from matches scheduled to use a pink ball.[9] Findings indicate that players consider the visibility of the pink ball to be significantly worse than the visibility of the red ball under normal daylight conditions whilst batting *and* fielding, with any difficulties most pronounced when playing at dusk even though floodlights are used at that time. A consideration when interpreting results from this study is that there has only been a limited amount of domestic day/night cricket played in the United Kingdom using the pink ball. It is therefore possible, that the relative limited experience of the participants playing with a pink ball may have impacted their responses.

The findings of this study have important implications for the safety of those playing with the pink ball, particularly at dusk. Cricket can be a fast-paced sport in which batters, when facing pace deliveries, must defend themselves against a fast-moving ball that is hard[21] and is sometimes deliberately projected towards them. Injuries are not uncommon in cricket, sometimes occurring when a player misjudges the trajectory of the ball when batting or fielding.[21,22] Cricket ball related injuries have recently been the cause of player concussion, and even death.[23] Intuitively, any decrease in the visibility of the ball will increase the level of danger faced by cricketers. It is for this reason that play is either suspended or stopped when lighting decreases below a critical level in red ball cricket, even during the daytime (it would be interesting to establish visibility in this scenario with the red ball to those at dusk and

night with the pink ball). The results of this study show that players perceived that visibility is poorer with the pink ball, in particular at dusk. It remains unclear whether it is the pink ball itself which presents the difficulty at dusk, or rather whether any coloured ball (including white) might be more difficult to see in those lighting conditions. The results provide justification for administrators to at the very least reconsider scheduling play at dusk using the ball colours currently available to them, and instead should consider longer breaks in play to be scheduled during this period to enhance player safety.

It has been hypothesised that the visibility of the pink ball would be poorest at dusk, particularly with the sky as a backdrop, because of difficulties in perceiving the motion of the ball when set against an equiluminant (omitting equal levels of light intensity) background.[4] We show that player opinions are consistent with this claim. Despite ~90% of players reporting they did not change their batting or fielding style to accommodate the pink ball, free text comments suggest otherwise. These comments suggest that the limited visibility of the pink ball does require at least some players to make adjustments to their game to accommodate the changes in playing conditions. It would perhaps be more concerning if more players were forced to change the way they play to accommodate the pink ball.

Batting was perceived to be more difficult when batting against pace (faster) bowling than against spin bowling. Presumably this would be related to the faster gaze tracking required to follow a faster ball trajectory[13,24] and with reduced time to pick-up vital anticipatory information regarding ball trajectory.[10,11,12] When batting against a pace bowler, research has shown that after the bowler releases the ball, elite batters do not visually track the approaching ball along its entire trajectory, but instead track initial ball flight before initiating a predictive saccade towards where the ball will bounce on the pitch and then again to the point of bat-ball contact.[13] The inherent conditions at night, and in particular at dusk may impact a batter's ability to adequately pick-up ball-flight information to make the rapid predictive saccade required for success. It is also possible that such light conditions may impact the batter's ability to acquire relevant information from the bowler's body before release. Research is warranted to determine the degree to which lesser lighting conditions impact the visibility of the ball and any subsequent impact on the ability to pick-up advance bowler postural cues and early ball-flight information.[25]

In this study, a number of players reported that the pink ball can appear to be blurred or to 'streak' under floodlights at night. For instance, free-text comments included that the pink ball "seemed a bit of a blur", "isn't clear, almost seems a bit of a blur", and "leaves a trail". Descriptions of the ball appearing blurred are consistent with a shift to greater integration times for low contrast information,[26,27] and possibly could be a result of greater reliance on short wavelength retinal cones (photoreceptors) at dusk because they also have a protracted integration time (they average input over longer time periods).[28] These effects could potentially be emolliated by using chromatic filters that enhance brightness contrast.[16] Future research should explore the effects of different coloured filters during in-play situations, in particular to establish any benefits for athletes (with and without a colour vision deficiency).

Information was collected about each players' level of experience with the pink ball to establish whether any difficulties in visibility would subside with increased experience. However, results revealed a very weak relationship between a player's experience with the pink ball and ratings of visibility when batting or fielding. What was surprisingly evident though was that players so far had very little experience playing and training with a pink ball. The results suggest that players may be surprisingly ill-prepared for the different conditions they may encounter when playing with a pink ball in competitive matches. Clearly if the pink ball is 'here to stay', then teams (and individuals) may benefit from more exposure to training and/or playing with a pink ball to become more accustomed to the unique challenges they face during genuine play.

As noted, the visibility of the pink ball may be particularly difficult and represent challenges for the performance and safety of players with a colour vision deficiency.[7,29] Three participants in this study self-reported a colour vision deficiency, which is relatively fewer than what would have been expected on the basis of frequency in the male population (about 8% of males). Either some players remain unaware of their colour vision deficiency, or rather that our results are consistent with others who have found an underrepresentation of individuals with a colour vision deficiency in first-class cricket[30], further supporting the idea that a colour vision deficiency may present a potential barrier to optimal performance in cricket.

It is important to recognise the following limitations of the study; with the number and frequency of day/night cricket matches using a pink ball being low, the exposure to matches using a pink ball of the participants recruited is relatively low. There is a possibility that some of the responses given are due to inexperience or lack of exposure. The comparison between the pink ball under different lighting conditions with the red ball under natural daylight conditions may be confusing as the red ball not is not used under floodlights.

In this study we have examined the suitability of the pink ball for use in the longer format(s) of the game, so it remains unclear whether the pink ball provides better visibility than would a white ball (or any other colour). If the pink ball were to provide better visibility than the white ball, then the pink ball could offer promise for use in one-day and T20 matches. However, the converse is unfortunately not true: a white ball made using current technology cannot offer a suitable alternative to the pink ball for longer matches, even if it is easier to see, because the white ball quickly becomes discoloured. It is for this reason that the visibility of the pink relative to the white ball was not evaluated. It does remain possible that other colours may be more suitable for use in longer games, in which case studies can be designed to evaluate those colours in comparison to the pink and indeed the traditional red ball. These studies may consider mathematically modelling the visibility of coloured cricket balls against different backgrounds faced during the different lighting conditions experienced in a day/night cricket match. Additional work is also required to gather the perspectives of umpires within the game as their views would aid in shaping future empirical research.

5. Conclusion

Professional cricket players report that a pink cricket ball is less visible than a red ball whilst batting *and* fielding. These difficulties are predominantly experienced at dusk (under floodlights), and to a lesser extent at night. The difficulties were greater when batting against pace (faster) bowling than they were against spin bowling. Given the implications for player safety, cricket governing bodies should consider the inclusion of longer breaks in play during dusk to avoid this most visually challenging lighting conditions.

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Appendix A. Supplementary data

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