

# Abnormal colour vision is a handicap to playing cricket but not an insurmountable one

*Clin Exp Optom* 2007; 90: 6: 451–456

DOI:10.1111/j.1444-0938.2006.00180.x

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**Background:** Two studies have reported that abnormal colour vision is under-represented among cricketers, presumably because cricketers with abnormal colour vision have difficulty seeing the red ball against the green grass of the cricket field and the green foliage around it. We have previously reported on the difficulties of five cricketers with abnormal colour vision but we have also reported that one of Australia's finest cricketers was a protanope. This survey was undertaken to confirm the under-representation of abnormal colour vision among cricketers and to ascertain whether those playing tend to be (1) those with a mild colour vision deficiency, (2) bowlers rather than batsman and (3) prefer to field close to the batsman rather than in the outfield.

**Methods:** The colour vision of 293 members of seven Melbourne Premier cricket clubs was tested using the Ishihara test. Those who failed were examined further to confirm their abnormal colour vision, to assess its severity with the Farnsworth D15 test and to classify it as either protan or deutan using the Medmont C100 test. A questionnaire about cricketing ability and problems playing cricket was administered.

**Results:** Twenty-six (8.9 per cent) of the cricketers had abnormal colour vision, of whom six played in the First Grade (6.7 per cent of First Grade players). The proportion of cricketers with a severe deficiency was significantly less than expected for the First Grade players. There were only two protans. Bowlers were not over-represented among the colour vision defective cricketers but those preferring to field close to the batsman were significantly over-represented.

**Conclusion:** Abnormal colour vision is a modest handicap to playing cricket, especially at the higher levels of the game. It may impede batting and the ability to field in the outfield.

Submitted: 15 February 2007

Revised: 18 April 2007

Accepted for publication: 14 May 2007

Key words: colour blind, vision and sport

Cricket is a game played with a bat and a red ball that is often seen against green surrounds: the green grass of the ground, green trees or grass surrounding the cricket field and possibly green seats in spectator stands. Cricket is mostly played by men and eight per cent of men have a

red-green colour vision deficiency,<sup>1</sup> some of whom could well have difficulty seeing the ball, since those with a more severe colour vision deficiency will see the red ball and green surrounds as having much the same colour. They would have to rely more on brightness contrast to distinguish

the ball. This is illustrated in an earlier paper,<sup>2</sup> in which we showed the chromaticity co-ordinates of a new and old cricket ball in relation to the confusion loci of protanopes and deuteranopes and the chromaticity co-ordinates of grass and green clothing. In that paper, we also

reproduced simulations of the colour appearance of cricket balls on grass for dichromats to show how colour contrast was reduced.

The lack of strong colour contrast between ball and grass might cause cricketers with abnormal colour vision to under-perform in batting and fielding and cease to play. If this is the case, abnormal colour vision should be under-represented among cricketers. Goddard and Coull<sup>3</sup> showed that the prevalence of abnormal colour vision was four per cent for 280 first class County cricketers in England, who were tested with the Ishihara test. This was statistically significantly less than the expected eight per cent. In a survey of 100 district and sub-district cricketers in Australia, Brown and Couper<sup>4</sup> found only three per cent failed the Ishihara test but the 95% confidence limits are 0.65 to 8.83 per cent so this apparent under-representation does not reach statistical significance. Nevertheless, these two studies suggest that self-selection for abnormal colour vision occurs among cricketers. Neither of these two studies investigated the nature of the colour vision defect of those who were successfully playing cricket and we hypothesise that the three to four per cent of cricketers continuing to play cricket are those with mild colour vision deficiencies.

The five colour defective cricketers reported in our earlier paper<sup>2</sup> were all mild deuteranomalies. We asked them detailed questions about their experiences when fielding and batting. Although they reported some incidents of difficulty seeing the red ball, which might be attributable to their colour vision deficiency, they all managed to play well.

In the course of our earlier studies of colour vision deficiency and cricket, we were told that Bill Ponsford was 'colour blind'. Bill Ponsford was one of Australia's most successful cricketers, especially with the bat, although he was also well regarded as a fielder.<sup>5</sup> We hypothesised that he too would have a mild colour vision deficiency, probably mild deuteranomaly, like the five cricketers we surveyed. He died in 1991, so we undertook a posthumous diagnosis by testing the

colour vision of his descendants. We concluded that he was a protanope,<sup>6</sup> although there is a very small possibility that his mother was a mixed heterozygote and that he was not a protanope but a mild deuteranomaly,<sup>7</sup> however, we think this is very unlikely.<sup>8</sup> If he was a protanope, as is most likely, this raises doubt about whether abnormal colour vision is an impediment to playing cricket at the highest levels.

We undertook this survey of cricketers to confirm that abnormal colour vision is under-represented among cricketers, as reported by Goddard and Coull<sup>3</sup> and Brown and Couper.<sup>4</sup> We also set out to assess the type and severity of the colour vision deficiency of those cricketers who were shown to have abnormal colour vision, to test the hypothesis that those who continue to play cricket have a mild colour vision deficiency. In addition, we planned to ask the cricketers with abnormal colour vision the same kind of questions we asked of the five cricketers, whose experiences we have already reported,<sup>2</sup> to extend the size of the sample and to test the hypotheses (1) that the colour vision deficient cricketers are preferentially bowlers rather than batsmen and (2) prefer to field near the batsman, where the ball subtends a larger angle, rather than in the out-field.

## METHOD

We tested the colour vision of 293 Premier cricketers playing at first, second, third and fourth grade levels using the 1968 24-plate and 1978 24-plate editions of the Ishihara test. The grade level refers to the teams in which they currently played—the first XI, second XI et cetera. The colour vision of those who failed the Ishihara test was further assessed by the senior author, repeating the Ishihara test using the 1968 24-plate edition, then using the Medmont C100 test (Medmont Pty Ltd, Vermont, Victoria, Australia), to differentiate protan and deutan colour vision deficiencies and the Farnsworth D15 (The Psychological Corporation, New York, NY) to categorise them as having a mild or a moderate-to-severe deficiency. We also administered the same questionnaire that was given to

the five cricketers whose experiences have already been reported.<sup>2</sup>

The project was approved by the joint ethics committee of the Victorian College of Optometry, the National Vision Research Institute of Australia and the Department of Optometry and Vision Sciences of The University of Melbourne.

To gain access to a large number of active cricketers, Cricket Victoria was approached and given details of our proposed study. Cricket Victoria wrote to nine Premier cricket clubs in the City of Melbourne, making them aware of the study and suggesting they participate in it. Administrators of these nine Premier clubs were contacted and seven clubs agreed to participate. Arrangements were made to screen all players in each of these seven clubs for defective colour vision, using the player lists provided by the clubs.

Players were screened with the Ishihara test at their club grounds at the beginning or the end of a scheduled training session. We attended three training sessions for each club to screen as many of the listed players as possible. The coaches were also tested to illustrate the procedure and gain their support in recruiting all their players and although two of the coaches had abnormal colour vision, they have not been included in the study sample because they were not currently playing cricket.

When players who were listed as members of the clubs were not available over three screening sessions, the coach was asked for an explanation. In some cases, the players lived in the country, or played State cricket and did not attend club practice sessions but mostly, those we could not contact were no longer active members of the club. We were able to screen the colour vision of many country players and the State players who did not attend regular training sessions in Melbourne by attending weekend matches in which they had been selected to play.

Up to three optometrists were involved at each screening. One explained the purpose of the study to each player and obtained signed consent. The players then proceeded to the other optometrists and

	Number on player lists	Number screened	Percentage not screened	Number with abnormal colour vision	Percentage	95% confidence limits
1st grade cricketers	101	90	11.9	6	6.7	2.5%–12.6%
Other grade cricketers	237	203	14.3	20	9.8	5.5%–12.7%
Total cricketers	337	293	13.1	26	8.9	5.3%–11.1%

**Table 1. Number of cricketers on club player lists, number screened and number and percentage with abnormal colour vision**

were tested with the Ishihara test on a one to one basis in the privacy of the clubroom or at the edge of the ground in daylight. The rooms were illuminated with daylight fluorescent lights and outside the plates were positioned so they were illuminated by skylight and not direct sunlight.

The lack of precise control of illumination was necessary because the cricketers were impatient to start training or to get home. Cricketers would have been lost to the study if they had to be marshalled into a room to wait to be tested at a desk. The Ishihara is a robust test that is known to perform well under widely varying levels of illumination and widely varying colour temperatures. Dain<sup>9</sup> calculated that there is very little shift in the chromaticities of the colours of the Ishihara test for a range of different fluorescent light sources compared to Illuminant C and the Macbeth lamp. Schmidt<sup>10</sup> found that varying illumination from 269 lux to 700 or even 1,076 lux had no significant effect on average Ishihara errors, with the possibility that errors might reduce at high illuminances for observers with abnormal colour vision. Colour temperature has a greater effect, with errors decreasing by about 12 per cent on average as colour temperature drops from 11,000 K to 3,000 K but up to 40 per cent for some individuals.<sup>10</sup> The daylight fluorescent lights in the cricket club rooms would have had a correlated colour temperature of the order of 5,000 to 6,000 K and skylight colour temperatures at the time of testing the cricketers (4.30 pm to 6 pm solar time) would have had a colour temperature of 5,000 to 6,000 K,<sup>11</sup> a little lower than 6,777 K of Illuminant C. This might have the effect of reducing errors, raising the risk of mis-

ing a small number of mildly affected anomalous trichromats. Most of those with abnormal colour vision make many errors with the Ishihara and will still fail even if the testing conditions are likely to reduce the number of errors.

A fail of the Ishihara test in this study was three or more errors. The smallest number of errors made by observers with abnormal colour vision is about six errors and only five to 10 per cent make fewer than 10 errors.<sup>1,12</sup> In his sample of 40 with defective colour vision, Cole<sup>13</sup> found one subject who made only three errors, with the next smallest number being six errors. Even if the number of Ishihara errors was reduced by as much as 40 per cent as a result of low colour temperature or high daylight illuminance, all colour vision abnormal subjects would still be expected to fail the test with the fail criterion of three or more errors.

Every player who failed the Ishihara provided personal details to the senior author who contacted them later to arrange a more detailed assessment under more controlled conditions.

The follow-up assessment included repeating the Ishihara test followed by the Medmont C100 test to separate protans from deutans and the Farnsworth D15 test to grade the severity of the defect. The follow-up visits were conducted in players' homes, at their workplace, in private optometric rooms or at the Victorian College of Optometry under daylight fluorescent light.

The questionnaire was then administered. There were 25 questions which covered their prior knowledge of their abnormal colour vision, their cricketering record and explored if they could recall

any event that occurred during a cricket match that may have been the result of their colour vision problem. The questions about problems playing cricket were not directive or related to colour or colour blindness. They took the form 'Do you have any particular problems with batting, fielding et cetera' or 'Are there any particular circumstances when you have trouble seeing the ball?'

## RESULTS

A total of 293 Premier level cricketers from seven clubs were screened for defective colour vision. Twenty-seven failed the screening but on follow-up one was found to have normal colour vision. Two were not available for further testing, so details of their colour vision and cricket ability are unknown, however, they are included in the results as having failed the screening. Neither of these two cricketers played in the first grade.

Two pairs of brothers who had defective colour vision have been counted as four individual players. It is common for members of the same family to participate in cricket, so there is a risk of over-representation of abnormal colour vision because abnormal colour vision is inherited. The outcome of statistical analyses is the same whether both brothers of the two pairs of brothers are included or one of each pair was excluded.

Table 1 shows the number of cricketers screened, the percentage of players on the club lists who were not screened and number and percentage who had abnormal colour vision. The prevalence of abnormal colour vision for the cricketers is clearly not significantly different from

	Mild CVD Pass D15 test		Severe CVD Fail D15 test		Total
	No.	Expected*	No.	Expected*	
1st grade cricketers	6	2.5	0	3.5	6
Other grade cricketers	9	7.6	9	10.4	18
Total cricketers	15	10.1	9	13.9	24

\* 42% of CVD fail the Farnsworth D15 (see text)

**Table 2. Numbers and percentage of cricketers with abnormal colour vision by degree of severity**

	Deutan		Protan		Total
	No.	Expected*	No.	Expected*	
1st grade cricketers	6	4.5	0	1.5	6
Other grade cricketers	16	13.5	2	4.5	18
Total cricketers	22	18.0	2	6.0	24

\* It is known that the prevalence of protan is two per cent and deutan is six per cent, so expected numbers should be in the proportion 0.25 for protans and 0.75 for deutans.

**Table 3. Number and percentage of cricketers with abnormal colour vision by type**

the expected prevalence of eight per cent for the general male population. The prevalence of abnormal colour vision for the First Grade cricketers is numerically lower than that among the other grades of cricketers but it too is not significantly different from the general population prevalence.

Table 2 shows the numbers of cricketers who passed the Farnsworth D15 test and have a mild colour vision deficiency and who fail it and have a moderate to severe deficiency, compared to the expected number in each of these two categories.

The expected numbers passing and failing the Farnsworth D15 test in Table 2 are based on an expected 42 per cent pass rate. This expected pass rate is based on five studies. Farnsworth<sup>14</sup> states, on the basis of testing 2,146 males with the D15 test, five per cent of the general male population will fail it. Assuming that eight per cent have abnormal colour vision, three out of eight (38 per cent) of those with

abnormal colour vision will pass the D15 test. Dain and Adams<sup>15</sup> report a 29 per cent pass rate (n = 75) but observe that their sample may be biased to those with more severe deficiencies. Hovis, Lu and Neumann<sup>16</sup> (n = 29) and Cole and Orenstein<sup>17</sup> (n = 102) both report a pass rate of 41 per cent. The latter study probably has a representative sample, as it was drawn from consecutive patients in an optometric practice presenting for reasons other than colour vision assessment. On the other hand, Cole and colleagues<sup>18</sup> (n = 99) report 60 per cent passing but their sample was drawn from patients referred to a colour vision clinic and is not necessarily representative of the whole CVD population. The weighted average of these five studies is a pass rate of 42 per cent, which is the pass rate assumed in Table 2. If the Cole and colleagues' study<sup>18</sup> is excluded, the weighted average pass rate of the other four studies is 37 per cent.

The number of cricketers who pass the Farnsworth D15 test is not significantly higher than the expected number (Chi square = 3.34, df = 1, p > 0.05 < 0.1), however, it is significantly higher for the cricketers in the first grade (Chi Square = 6.08, df = 1, p < 0.025). It is even more significant if the expectation is based on a pass rate of 37 per cent (Chi Square = 7.7, df = 1, p < 0.01). The number of cricketers in the other grades of cricket who passed the Farnsworth D15 test is not significantly different from the expected numbers, regardless of whether the expected pass rate is taken to be 42 or 37 per cent.

Table 3 shows the numbers diagnosed as protan and deutan by the Medmont C-100 test compared to the expected numbers. Although the number of protans is less than expected, the difference is not significant. There were no protans among the group of six cricketers with defective colour vision who play in the first grade but this does not differ significantly from the expected number.

Tables 4 and 5 summarise information obtained from the questionnaire.

## DISCUSSION

The previous studies of abnormal colour vision and cricket<sup>3,4</sup> show that abnormal colour vision is under-represented among cricketers, presumably because they have difficulty sighting the red ball against green surrounds, although protanopia did not stop Bill Ponsford being one of Australia's all time best batsmen.<sup>5,6</sup> In our survey, the prevalence of abnormal colour vision was not significantly less than the expected eight per cent (Table 1) but our results are nonetheless consistent with the earlier reports.

We find that severe colour vision deficiency is significantly under-represented in the first grade cricketers (Table 2). It follows that the overall prevalence of abnormal colour vision in this group of cricketers must be less than that in the general population. The true prevalence will be toward the lower end of the 95% confidence interval, which for the first grade cricketers is 3.1 per cent (Table 1).

Average age (years $\pm$ SD)	23.3	( $\pm$ 6.9)
Aware of colour vision deficiency (number and percentage)	14	58%
How became aware (number and percentage)		
Diagnosed by an optometrist	3	21%
Mother's observation	2	14%
Teacher's observation	2	14%
Test at school	5	36%
Family knowledge of CVD	2	14%
Batting and bowling (number and percentage)		
Specialist batsman	7	29%
All rounder	9	37%
Wicketkeeper	3	13%
Bowler	5	21%
Present batting average (runs per innings played)*		
Mild CVD	28.3	
Severe CVD	18.8	
Preferred/usual fielding position <sup>†§</sup> (number and percentage)		
In-field	11	46%
Mid-field	12	50%
Out-field	1	4%
Does sight screen help? (number and percentage)		
Definitely	1	4%
Yes	7	29%
Maybe	4	17%
No or don't know	11	46%

\* Differences between mild and severe CVD are not significant  
<sup>†</sup> The number fielding in the out-field is significantly different from expected, assuming that one third of players normally field in the outfield (Chi sq = 9.2 df = 3 p < 0.01)  
<sup>§</sup> Respondents were asked both their preferred and usual fielding positions but almost invariably the answers were the same

**Table 4. Summary of information obtained from the questionnaire**

	Mild CVD	Severe CVD
Number of problems playing cricket		
Number reporting no problems	7	1
Number reporting 1 or 2 problems	9	3
Number reporting more than 2 problems	0	4
Most commonly reported problems		
Lose sight of ball running on grass, especially when it stops	1	3
Seeing ball against trees/bushes	2	2
Seeing the ball when no sight screen	2	0
Seeing the ball under overcast conditions	5	0
Plays better with white ball	2	0

**Table 5. Reported problems playing cricket**

The data also suggest that protan colour vision deficiency may be under-represented (Table 3). Although the number of protan cricketers in this study was not significantly less than the expected number, it approaches significance and the difference becomes significant (Chi Square = 4.85, df = 1, p < 0.05) when the five cricketers reported previously,<sup>2</sup> all of whom had a deutan defect, are added to the sample.

It can be hypothesised that abnormal colour vision will be an impediment for batting but not for bowling, so that cricketers with abnormal colour vision might preferentially be bowlers. There is no support for this hypothesis in the data of Table 4. Cricket teams normally field four specialist bowlers in the 11-person cricket team, which is 36 per cent. Table 4 shows that only 21 per cent of the 24 cricketers with abnormal colour vision were bowlers.

It can also be hypothesised that cricketers with severe colour vision will have a lower batting average (average runs per innings) than those with a mild deficiency. Table 4 shows that those with a mild colour vision deficiency have a higher batting average than those with a severe deficiency but the difference is not significant. Goddard and Coull<sup>3</sup> found that their colour vision deficient cricketers did not have a lower batting average than colour vision normal cricketers but abnormal colour vision was under-represented in their sample of cricketers, presumably because those with a severe deficiency had not been selected to play at the first class County level.

We were surprised that the cricketers with defective colour vision did not have strong views on the value of sight screens as an aid to batting (Tables 4 and 5), although in part this was because the lower grade cricketers rarely played with sight screens. One successful colour defective cricketer said he was a bowler from the outset of his career but on reaching the grade of cricket where sight screens were used, he became a high scoring batsman. Another said he had organised for a sight screen to be built at his home ground because it was such a help to him. He also said he had problems with very tall bow-

lers who delivered the ball from above the sightscreen.

A further hypothesis is that cricketers with abnormal colour vision will have greatest difficulty when fielding in the outfield where the angular size of the ball is small and the ball may often be seen against grass or surrounding foliage. The ball subtends about 12 minutes of arc for a fielder close to the batsman and three to five minutes of arc for a fielder near the boundary. It is known that all observers with abnormal colour vision, even those with a mild deficiency, have difficulty seeing red objects in natural surrounds.<sup>19</sup> For these reasons cricketers with abnormal colour vision should prefer to field close to the batsman. Table 4 shows that this is the case: a significantly greater number of the cricketers with abnormal colour vision prefer to field close to the batsman rather than in the outfield (Chi Square = 9.2, df = 2,  $p < 0.01$  assuming an expectation that there are equal numbers of in-field, mid-field and out-field fielders). The hypothesis is also supported by comments made by the cricketers (Table 5).

Four of the CVD cricketers in our sample, three of whom had a severe colour vision deficiency, reported difficulty seeing the ball running on the grass of the field, especially when the ball stopped moving. One recalled an especially embarrassing incident chasing a ball running along the grass in the outfield. He looked back momentarily to decide to which end of the batting pitch he should throw the ball when he picked it up and during that moment the ball stopped and he was unable to find it. The batsmen kept scoring runs and his team mates hurled abuse.

Our data suggest that self-selection because of abnormal colour vision may occur only at the higher levels of cricket, as abnormal colour vision seems to be under-represented only in the First Grade cricketers and not the other grades. This may be the reason we did not replicate the results of Goddard and Coull<sup>3</sup> who found the prevalence of abnormal colour vision was significantly under-represented among their 280 first class County cricketers. Our sample was drawn from district club cricket rather than from first class cricket.

It is disappointing that such a large proportion (42 per cent) of our sample did not know they had abnormal colour vision. This means either that young people do not always have an eye examination or if they do, their colour vision is not tested, as it should be for all patients seen for the first time.<sup>20</sup> Of those who did know they had abnormal colour vision, only three (21 per cent) knew because of an eye examination (Table 4).

We conclude that abnormal colour vision is a modest handicap to playing cricket and that cricketers with abnormal colour vision, especially those with a severe or a protan deficiency, tend not to reach the highest levels of cricket. They will have most difficulty with fielding. Optometrists who do test the colour vision of all their patients can tell those who have a severe or protan colour vision deficiency that this may affect their ability to succeed at the highest levels of cricket, unless of course they have the talent of Bill Ponsford.

#### ACKNOWLEDGEMENTS

We thank Andrew Harris and David Southgate who helped with the collection of data and Cricket Victoria who encouraged the cricket clubs to participate in the survey. We appreciate very much the co-operation of the club managers, coaches and the players who allowed us to interrupt their training sessions. We are grateful to the cricketers with abnormal colour vision who with only two exceptions gave their time for the follow-up assessment.

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