Doctors and the assessment of blood glucose testing sticks: does colour blindness matter?

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SUMMARY

A group of doctors with congenital colour vision deficiency (CCVD) were compared with a group of controls in their assessment of colour blocks in the colour range of a widely available blood glucose testing stick. The majority of doctors with CCVD agreed with controls on colour matching. However, subjects with severe CCVD tended to match test blocks to a wider range of options than either those with a less severe defect or controls. This paper discusses the implications of these findings.

Keywords: *congenital colour vision deficiency; glucose testing; doctors.*

Introduction

WE have previously reported the results of investigations in which doctors with congenital colour vision deficiency (CCVD) reported a range of difficulties encountered in clinical practice[1] and were observed to differ from controls in their assessment of clinical photographs.[2] One area of reported difficulty was in the assessment of colour-coded stick testing of blood glucose levels. Allwood and Tyler[3] and others[4] have documented difficulties encountered by diabetic patients with CCVD in the dipstick assessment of urinary glucose. This investigation aims to provide objective evidence of the reported difficulty encountered by doctors with CCVD in the assessment of stick tests of blood glucose levels.

Method

Detailed methods have been presented previously.[2] Twenty-three general practitioners (GPs) aged less than 60 years (all except one were male) and members of the Royal College of General Practitioners (RCGP) who had a known CCVD were compared with a control group of 28 male doctors (also members of the RCGP and aged less than 60 years) who did not have a known CCVD. The severity of CCVD was ascertained using a battery of tests, including the Nagel anomaloscope, Farnsworth D15, City University,[5] and the American Optical HRR Company[6] tests, administered under standard conditions. Subjects with CCVD had a mild, moderate, or severe colour vision problem in five, five, and 13 cases respectively.

Subjects were asked to match a colour block from the Glucostix (Bayer Diagnostics) test card — which uses colours in the orange, red, and green range — against a reference chart made up of nine 11mm diameter discs (a–i), whose colours corresponded to the nine possible colour options equivalent to the following blood glucose levels (mmol/l): 1, 2, 4, 6, 8, 10, 14, 22, or 44 (levels are not ordered sequentially on the chart). Each block on the test card measured 6mm^2 and had a central circular perforation of 3mm, allowing participants to compare the colours by overlying the test card against the reference chart and visually matching colours through the central perforation. Matching was repeated for each of the four colour blocks from the test card equating to blood glucose levels of 1, 6, 8, or 22 mmol/l. In almost all cases, the examination of investigative material was carried out using a fluorescent light source with a colour rendering index greater than 19[7] to illuminate test material, or in a north-facing window at about midday (11.00am–1.00pm).

Performance with each test card was analysed by counting the number of subjects in each group who matched the card to an option on the reference chart more than one step away from the correct one. Where a subject provided alternate responses — that is, matching a test card colour to 'either a or b' — and one of the alternatives was within one step of the correct response, it was not counted as a more-than-one-step error. The proportion of doctors with severe CCVD making such an error was compared with the proportion in the control group using Fisher's exact test. Confidence intervals of 95% for the proportions in each group were calculated using an exact binomial method; a 95% confidence interval for the difference between proportions in the two groups was calculated using Newcombe's extension to the score method for a single proportion, with a continuity correction.

Results

In the four tests the majority of doctors with CCVD agreed with controls on colour matching (Table 1). For the test block equivalent to a blood glucose of 1 mmol/l, all the controls and 15 (65%) of the cases matched the test block to the reference block equating to 1 mmol/l. However, eight of the cases (all of whom were noted to have severe CCVD) matched the test block to a different reference option equivalent to blood glucose levels of 2 (two cases), 6 (one case), 8 (three cases), or 10 mmol/l (two cases). In this test, all of the cases with mild or moderate defects agreed with the controls.

A similar pattern was evident when examining the results of colour matching for blood glucose equivalents of 6, 8, or 22 mmol/l (Table 1). Although not all controls agreed on the precise colour match in each of the four tests, subjects with severe CCVD tended to match test blocks to a wider range of options than those with a less severe defect, or controls. One subject with severe CCVD matched the test block equating to a blood glucose level of 6 mmol/l to the reference block equating to a blood glucose level of 44 mmol/l. The performance of doctors with severe CCVD was significantly different from that of controls when matching colour blocks with equivalent blood glucose values of 1 or 6 mmol/l and, although not statistically significant, a similar trend was evident in the other two tests (Table 2).

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Table 1. Matching of test colour blocks against reference colour blocks by 23 doctors with CCVD and 28 controls.

Test block blood glucose concentration equivalent	Reference block glucose concentration equivalent	Controls (n = 28)	Mild CCVD (n = 5)	Moderate CCVD (n = 5)	Severe CCVD (n = 13)
1 mmol/l	1	28	5	5	5
	2	-	-	-	2
	6	-	-	-	1
	8	-	-	-	3
	10	-	-	-	2
6 mmol/l	4	7	3	2	1
	4 or 6	1	-	-	-
	6	20	2	3	7
	8	-	-	-	1
	14	-	-	-	1
	22	-	-	-	2
	44	-	-	-	1
8 mmol/l	1	-	-	-	1
	2	-	-	-	1
	8	25	5	5	8
	8 or 14	1	-	-	-
	10	1	-	-	2
	14	1	-	-	-
	22	-	-	-	1
22 mmol/l[a]	2	-	-	-	1
	4	-	-	-	1
	4 or 14	-	-	-	-
	14	6	-	2	2
	14 or 22	1	-	1	1
	22	18	5	2	7
	44	1	-	-	-

[a]Two non-responders from the control group.

Table 2. Performance of doctors with severe CCVD in comparison to controls when matching test colour blocks against reference colour blocks.

Test block blood glucose concentration equivalent	Controls (n = 28)			Severe CCVD (n = 13)					
	Number of errors >1 step	Proportion	95% CI	Number of errors >1 step	Proportion	95% CI	Differences in proportion	95% CI	Fisher's exact P
1 mmol/l	0	0%	0–15%	6	46%	20–74%	46%	21–70%	0.0005
6 mmol/l	0	0%	0–15%	4	31%	10–61%	31%	10–57%	0.007
8 mmol/l	1	4%	0–20%	3	23%	6–54%	20%	0–47%	0.86
22 mmol/l	0[a]	0%	0–16%	3	23%	6–54%	23%	4–50%	0.105

[a]Number = 26 (two non-responders).

Discussion

Some doctors with CCVD have problems in the assessment of normality in clinical photographs and have less confidence than controls in their description of such material.[2] From the results presented here, it appears that the assessment of blood glucose using widely available stick testing may be a further problem area for at least some doctors with CCVD. Doctors with a severe colour vision problem made more errors in these tests than those with a less severe or no problem. While it has been suggested[9] that a one-step error may be of no major clinical importance, some doctors with CCVD in this study apparently made errors considerably greater that this. Eight per cent of the male population in Caucasian countries have CCVD.[10] Spalding[1] has previously noted the lack of adequate prevalence studies examining CCVD in doctors but suggested that the available evidence pointed to approximately 2000 GPs and 3000 hospital doctors possibly being affected.

This study provides objective support for the conclusions of a previous qualitative survey of the cases in this study.[1] These results also support our previous conclusion that at least some doctors with CCVD need to take care in ensuring adequate back-up and corroboration for undertaking colour-dependent clinical assessments; for example, in some forms of stick testing of blood (and possibly urine). Furthermore, precise adherence to manufacturers' instructions supplied with diagnostic tests is important.

This has been a study of a small volunteer sample of doctors with CCVD. For practical reasons, reference blocks of precisely matched colours equivalent to the commercially available test colours were used rather than blood- and reagent-impregnated blocks. This has the advantage of using standard test material for all subjects. The results presented here should be confirmed in a larger, representative sample of doctors with CCVD. However, given the magnitude of some of the errors encountered, and taking account of the results of other recent studies,[1,2,9,11] we believe there may be a case for the screening of medical students and staff with a view to advising on the severity of any CCVD that might be present and counselling regarding any precautions that

might be deemed appropriate to clinical practice.

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