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CONTRAST SENSITIVITY IN ADOLESCENTS WITH DIABETES*

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Abstract

Due to the nature of diabetic retinopathy, early detection of visual dysfunction is important in diabetic patients. It has been demonstrated in the literature that contrast sensitivity testing can be used as an early index of change in the retina of diabetic patients. Most studies in this area have been conducted on adults. Forty nine diabetic subjects aged 12 to 18 years with normal visual acuity had contrast sensitivity assessed on the Vistech VCTS 6500. Their results were compared to a group of 202 age matched normal subjects. The results of this study reveal that adolescent diabetics show a decrease in contrast sensitivity function, when results are subject to statistical analysis, however the loss in contrast sensitivity would not necessarily be detected in a clinical situation.

Key words: *Contrast sensitivity, diabetes, adolescents, diabetic retinopathy, Vistech.*

INTRODUCTION

Diabetes Mellitus is a metabolic disease that results in an increase in blood glucose concentration due to a lack of insulin or the body opposing the action of insulin.[1] There are two forms of diabetes; insulin dependant diabetes mellitus (IDDM) and non insulin dependant diabetes mellitus (NIDDM).

Initial symptoms of diabetes include excessive urine production, excessive thirst, weight loss and tiredness. These symptoms can be controlled by altering diet (NIDDM) or by the use of insulin (IDDM). However, changes in the eyes of diabetic patients (diabetic retinopathy) can occur even when the symptoms are controlled.

Early diabetic retinopathy is thought to occur as a result of changes in the small blood vessels of the retina leading to a loss of their structural integrity. With progression of the disease changes to the retinal blood vessels include thickening and weakening of capillary walls. These changes lead to microaneurysms, haemorrhages, oedema, hard exudates and cotton wool spots. This is known as non proliferative diabetic retinopathy. Later the patients may progress to proliferative retinopathy consisting of either maculopathy and/or neovascularisation.[2]

As a result of the above-mentioned changes visual function can be disturbed in diabetic patients, even in the early stages of the non proliferative diabetic retinopathy.[3]

Recent literature has revealed that contrast sensitivity may be affected much earlier than visual acuity in patients with diabetic retinopathy.[4-9]

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The literature has suggested that there is a correlation between contrast sensitivity loss and the severity of retinopathy.[4-6] Two studies have suggested that the degree of loss visual function, as revealed by contrast sensitivity tests, may be related to the duration of diabetic retinopathy.[4,7] The majority of the studies include adult subjects only whilst others encompass a wide age range.

The present study reports on the contrast sensitivity function of adolescent IDDM patients aged 12 to 18 years. The aim was to ascertain if contrast sensitivity function was abnormal and, if so was the abnormality indicative of early visual dysfunction.

Previous research has shown that contrast sensitivity alters with monocular or binocular testing,[10] age[11-14] and sex.[15] As a result, in the present study non diabetic subjects have been compared to IDDM patients of the same age, monocular and binocular scores have been compared and a comparison of overall scores for each sex has been made.

METHOD

Summary of Groups Studied

Two groups of adolescents aged 12 to 18 years were studied.

Group I consisted of 49 subjects (18 males, 31 females) with IDDM with or without diabetic retinopathy (see Table 1). The mean age of this group was 14.8 years. The average disease duration was 7.8 years. Subjects were collected over six months from the Royal Alexandra Hospital for Children, in Sydney.

Group II consisted of 202 non-diabetic subjects (96 males, 106 females) from a secondary school in the north west of Sydney tested over one week. The mean age of the control group was 14.7 years.

TABLE 1
Number of IDDM subjects with and without retinopathy

Eye	No Retinopathy	Mild → Mod Background Retinopathy	Ungradable
Right	25	21	3
Left	30	17	2

Study Design and Selection of Study Sample

Each subject's visual acuity was assessed monocularly at 6 m and 1/3 m using a Snellen's chart. Cover test and Lang's Stereo Test were also performed as contrast sensitivity may also be affected by amblyopia,[16] refractive error and astigmatism.[17] Criteria for inclusion in the study was an uncorrected monocular visual acuity of 6/6 or better and N5, no strabismus and 550 seconds of arc on the Lang Stereo Test.

If the subject met all the criteria outlined above, he or she was then assessed using the Vistech VCTS 6500 at 3.05 metres.

Contrast Sensitivity Assessment

The Vistech VCTS 6500 was used to assess contrast in this study. This test was designed to assess contrast sensitivity using gratings of various spatial frequency and different contrasts under a specified illumination.

The Vistech test consists of 40 striped sine wave gratings divided into rows A to E which range from high to low contrast (see Diagram 1). Subjects were asked to identify the orientation of the gratings in each target they could see in each row in turn and to state when they could not see the gratings. The orientation of the gratings was randomised along each row.

The minimum contrast at which each grating could be seen (the contrast threshold), was recorded.

The luminance was checked with the light meter provided with the test and was kept constant from one area of the chart to another and also from one testing session to the next. Each subject was seated 3.05 metres (10 feet) from the chart.

The test was carried out monocularly and binocularly (as previous studies have demonstrated a difference in monocular and binocular scores[10]). The order of testing right eye, left eye or binocularly first was randomised by computer prior to the commencement of the study.

Statistical Analysis

In both groups the mean, maximum and minimum scores, range, and standard deviation

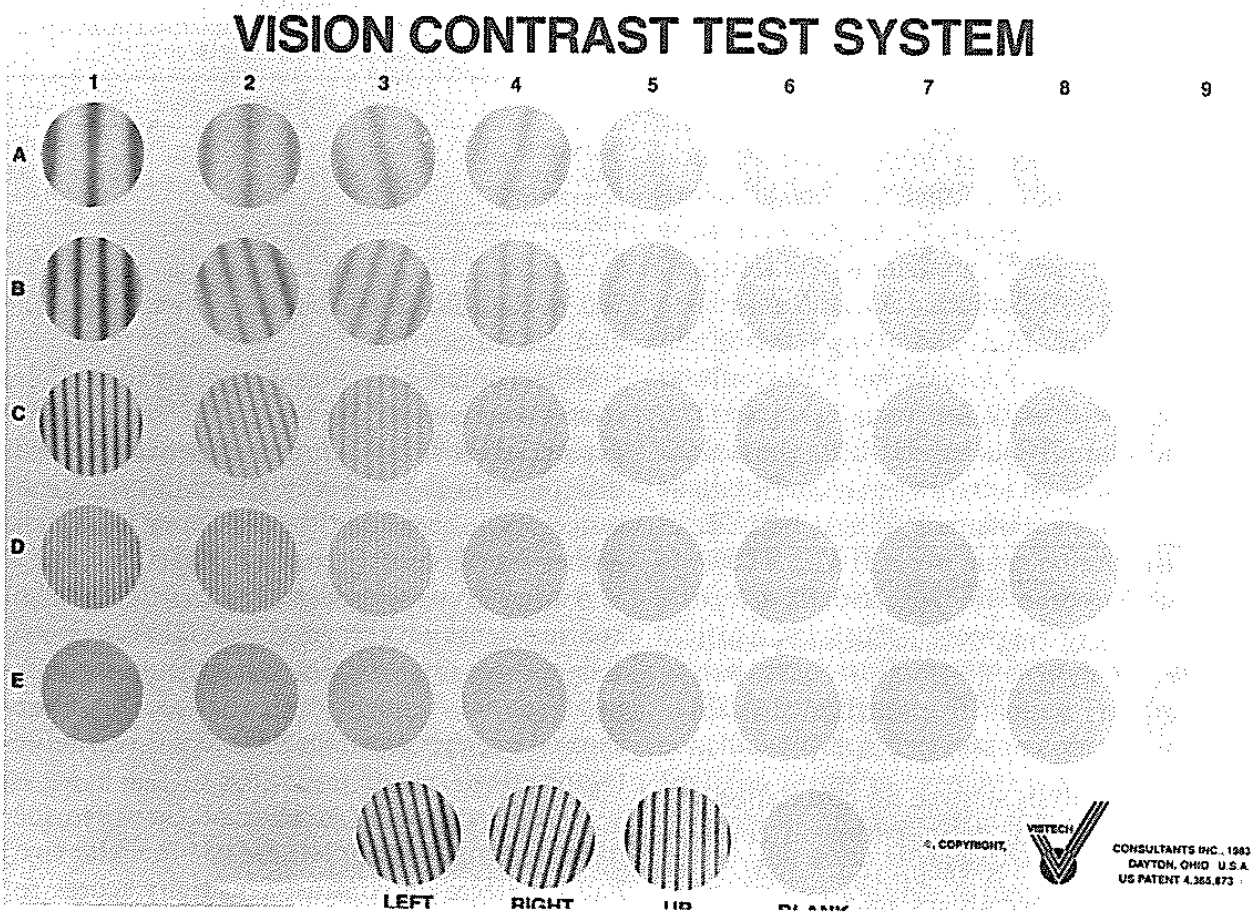

Diagram 1: Vistech VCTS 6500 chart

were calculated for all contrast sensitivity scores. The 5th and 95th percentiles were also calculated to enable direct comparison with the range of normals provided by Vistech. *T*-tests were also performed to compare the means of contrast sensitivity scores. The null hypothesis was that there would be no difference between the means in each group.

A correlation coefficient was calculated to look at the effect of diabetic retinopathy and the duration of the disease on contrast sensitivity function.

A one-way Analysis of Variance (ANOVA) was used to assess if the order of testing each subject's right eye, left eye or both eyes first had any influence on the contrast sensitivity scores for both the diabetic group and the control group.

Significance levels for all statistical tests was $p = 0.01$.

RESULTS

Figure 1 shows the range of normal contrast sensitivity scores using 5th and 95th percentiles for both groups. (For clarity of presentation, only the scores of the left eyes are shown in Figure 1). Diabetic scores falling within the control group range are considered to be normal. The diabetic group show a decrease in scores for the mid to high spatial frequencies, that is 6, 12 and 18 cycles per degree (cpd).

The results of the series of *t*-tests to analyse if there was any difference between the mean contrast sensitivity scores of both groups for each spatial frequency shows a significant decrease in all spatial frequencies for the right eyes and left eyes (see Table 2). Binocularly there was no difference between the two groups in rows A ($p = 0.06$) and B ($p = 0.413$). Otherwise findings were similar to the monocular results.

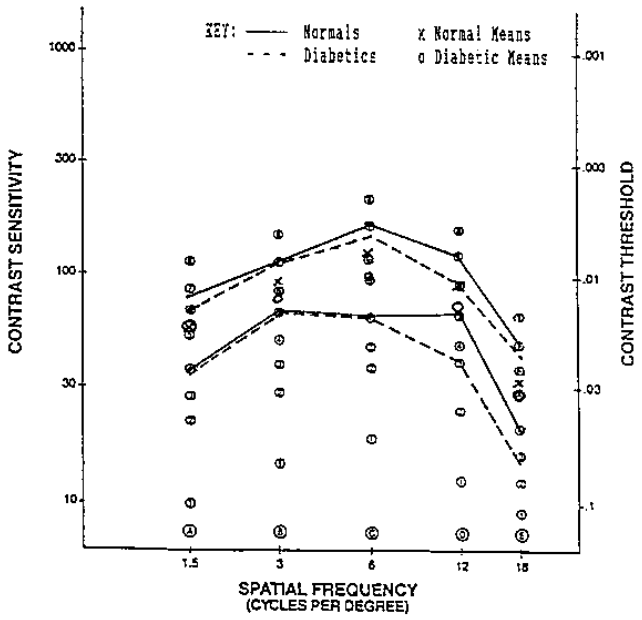

Figure 1: Monocular (LE) Contrast Sensitivity Function Curve on the Vistech VCTS 6500 test; Control versus diabetic subjects.

Statistical analysis showed no correlation for the effect of diabetic retinopathy on contrast sensitivity function for each eye.

The duration of diabetes had a significant effect on binocular scores in Row D ($r = -0.38$, $p = 0.004$). Likewise, a significant relationship was also found for the contrast sensitivity scores of the left eye in row E; ($r = -0.42$, $p < 0.01$). For all scores in row E some correlation coefficient values were significant and others were marginally significant (see Table 3; the negative 'r' values suggest the correlation is weak). There

TABLE 2
T-test for difference in mean contrast sensitivity scores of control group versus diabetic group; right and left eyes

Row	*t*	*p*
Right Eye		
A	2.88	0.004
B	4.60	0.001
C	4.27	0.001
D	4.87	0.001
E	4.00	0.001
Left Eye		
A	2.54	0.013
B	2.64	0.009
C	6.49	0.001
D	4.63	0.001
E	2.79	0.007

TABLE 3
Correlation showing duration of disease versus contrast sensitivity scores for row E (18 cpd)

	r Value	*p*
Right Eye	−0.23	0.056
Left Eye	−0.42	0.001
Binocular	−0.31	0.015

was no significant correlation between duration and the other rows.

When comparing monocular and binocular contrast sensitivity scores using 5th and 95th percentiles for both groups there was a subtle difference in the mid to high spatial frequency range with binocular scores being minimally higher (see Figure 2; control group results).

A *t*-test comparing monocular and binocular contrast sensitivity scores showed that there was a significant difference between the mean scores in all spatial frequencies. The binocular scores showed a higher mean than the monocular scores (see Table 4).

A one-way ANOVA, revealed that the order of testing (right eye or left eye or binocular first) had no effect on contrast sensitivity scores for the control group or the diabetic group.

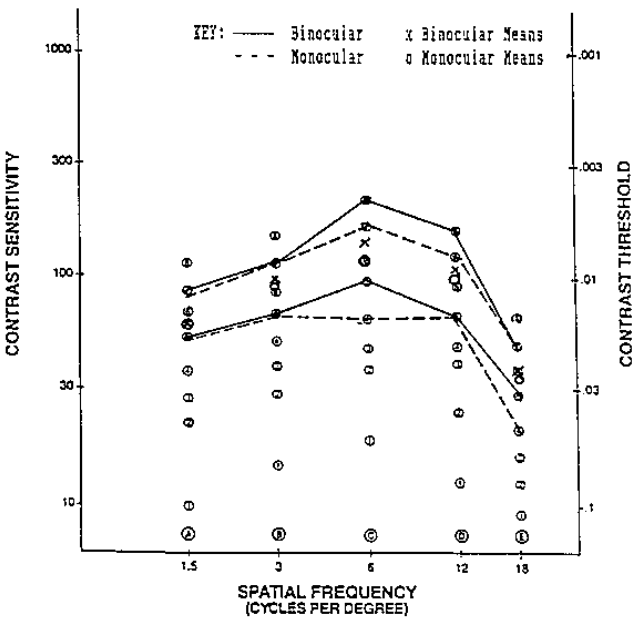

Figure 2: Control Group Contrast Sensitivity Function Curve on the Vistech VCTS 6500 test; Binocular versus Right Eye scores.

TABLE 4
T-test for contrast sensitivity scores of control group; right eye versus binocular

Row	*t*	*p*
A	− 4.39	<0.0001
B	− 4.87	<0.0001
C	−10.56	<0.0001
D	− 9.46	<0.0001
E	− 8.96	<0.0001

The effect of sex on contrast sensitivity scores was assessed using a *t*-test. The control group demonstrated that boys tended to score higher than girls for rows B, C and D ($p<0.01$). There was no effect of sex in the diabetic group.

There was a significant difference between the mean visual acuity for both groups. The diabetic group showed a significantly lower mean for both the right visual acuity and the left visual acuity.

There was no significant difference between the mean age for both the diabetic group and the control group. This was calculated by means of a *t*-test; $p=0.75$.

DISCUSSION

This study has demonstrated that adolescents with diabetes show a significantly reduced mean monocular contrast sensitivity for all rows when compared to age matched non-diabetics. When assessed binocularly they show reduced mean contrast sensitivity scores in the mid to high spatial frequencies only (rows C, D and E).

However, when comparing the contrast sensitivity functions of the diabetic group to the control group using 5th and 95th percentiles, the difference between the contrast sensitivity scores of both groups was not as great as comparing the scores using a *t*-test. At most, 5th and 95th percentiles show a slight decrease in the mid to high spatial frequency range. Unfortunately the score sheets provided with the Vistech VCTS only give 5th and 95th percentiles (means are not supplied). Therefore, clinically, the Vistech only requires the examiner to compare a patient's results to a normal population as marked by 5th and 95th percentiles to determine if scores are abnormal. Although statistically, diabetics may show reduced contrast sensitivity scores, clinically this will not always be apparent.

Investigators have found high spatial frequency loss,[5] low spatial frequency loss,[6] and non-selective spatial frequency loss,[7,8] when assessing contrast sensitivity in diabetics. Sokol et al[4] even found no contrast sensitivity loss in diabetics. Comparisons of contrast sensitivity results are difficult because different procedures, methods, equipment and techniques may produce different results.

Trick et al[7] used the Vistech VCTS 6500 in their study of diabetics and found a loss in all spatial frequencies with the most significant loss in the mid spatial frequency range. They also showed a difference in mean contrast sensitivity scores in diabetics when compared to normal contrast sensitivity scores. The results of the present study support Trick's findings.

Many investigators, including Trick et al[7] have concluded that a decrease in contrast sensitivity function seems to correlate with the severity of retinopathy.[4-9] However, other authors have not found that contrast sensitivity decreases before the presence of visible retinopathy in the diabetic eye.[4,6,7]

The findings in the present study indicate no relationship between the contrast sensitivity scores of diabetic subjects and the presence or absence of diabetic retinopathy. Della Sala et al[6] found no relationship of contrast sensitivity function to retinal pathology unless the diabetic retinopathy was gross. Trick et al[7] found a significant difference between the diabetics with retinopathy and the control group at 6.0 and 12.0 cpd. The subjects in this study had only mild to moderate background retinopathy or no retinopathy, which may account for the fact that no correlation was found.

The present study did show a correlation between contrast sensitivity function and the duration of diabetes for some scores in the high spatial frequency, (row E). This indicated that those subjects who had diabetes for the longest duration tended to score worse in row E. Sokol et al[4] reported a relationship between duration of diabetes and performance on contrast sensitivity tests similar to the relationship found in

the present study. They also reported a correlation between the presence or absence of retinopathy, the duration of diabetes and performance on contrast sensitivity tests. A negative correlation between contrast sensitivity function in row C and duration of diabetes was observed by Trick et al.[7]

One of the requirements for all subjects in this study was that they have a visual acuity of 6/6 or better. However, the diabetic group showed a significant reduction in visual acuity when compared to the control group, even though all subjects had to have what is considered to be "normal visual acuity". Although this visual reduction was revealed statistically, in a clinical situation this subtle difference would not be detected as a result of the gross nature of the Snellen type charts with many charts not testing to 6/4. As an aside it is interesting to note that many clinicians consider 6/6 to be normal visual acuity. These two groups of subjects clearly demonstrate that 6/5 can readily be reached in this age group. Similar findings have been reported in studies on younger age groups of Australian children.[18]

The diabetic group revealed a reduction on contrast sensitivity testing that would be more likely to be detected if scores were statistically analysed. However, as this does not occur in a clinical setting, contrast sensitivity scores would not necessarily alert the clinician to visual dysfunction.

Ross et al[10] reported a slight improvement in contrast sensitivity scores in adults when tested binocularly rather than monocularly. On comparison of binocular scores to monocular scores the results of the present study support Ross' findings. For binocular scores, all spatial frequencies were significantly higher than for monocular scores. As diabetic retinopathy may affect one eye substantially more than the other, these results suggest that, when assessing contrast sensitivity function of diabetics, monocular assessment gives the clinician more information about the individual visual function of each eye. It is also vitally important to compare all results to monocular age-corrected normals.

One finding of interest was that boys' contrast sensitivity scores were minimally better than those of girls when assessed with the Vistech VCTS 6500. A similar finding was reported by Fitzgerald[15] in a study of 606 visually normal children aged 6 to 12 years. Fitzgerald stated that, if there was to be an effect of sex on the outcome, one would have anticipated that girls would have scored better than boys. This is because most other studies on child development show that female children are more developed than male children of the same age.[19]

CONCLUSION

Statistical analysis of results in the present study reveal that adolescent diabetics show a decrease in contrast sensitivity function. Unfortunately the majority of the loss in contrast sensitivity would not be detected in a clinical situation.

The fact that no relationship was found between contrast sensitivity function and diabetic retinopathy, and that contrast sensitivity scores were not always abnormal in patients with known diabetic retinopathy, suggests that the Vistech VCTS 6500 Contrast Sensitivity Test is not suitable to predict which patients have sub clinical diabetic retinopathy or when diabetic adolescents are likely to develop retinopathy.

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