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Changes in Contrast Sensitivity in Young Adults with Diabetes

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Abstract

Background: This study compared contrast sensitivity and visual acuity of young adults with diabetes to that of controls and attempted to identify predictors of dry eye symptoms in patients with diabetes. **Methods:** This cross-sectional study, which included 37 patients with diabetes and 37 controls, was conducted in the Optometry Clinic of Kulliyyah Allied Health Science. All participants were aged between 19 and 39 years. Inclusion criteria were a diagnosis of diabetes without any evidence of ocular disease, abnormalities in colour vision or media opacity. **Results:** The contrast sensitivity significantly differed between patients and controls ($p = 0.045$). A multiple regression analysis showed that contrast sensitivity was a significant predictor of ocular symptoms in patients with diabetes, and this was statistically significant ($p = 0.002$). **Conclusions:** Contrast sensitivity may be affected during early ocular changes among young adults with diabetes. It may also predict the occurrence of dry eye symptoms in such patients.

Keywords: contrast sensitivity, diabetics, dry eye, young adult

Introduction

Dry eye disease (DED) is one of the most common complications reported by patients with diabetes,[1] with several studies reporting high prevalence rates.[1-4] Its symptoms include ocular discomfort (irritation, the sensation of a foreign body being present and redness) leading to diseases of the ocular surface,[5] blurred vision, burning sensation, irritation, photophobia and intolerance for contact lenses.[6] A somewhat subjective approach towards the diagnosis and treatment of dry eyes has been employed for a long time.[7]

Questionnaires represent an efficient way of subjectively self-assessing DED symptoms. The Ocular Surface Disease Index (OSDI), used as a standard measure for dry eyes,[8] has been reported to be both valid and efficient in distinguishing the severity of DED.[9] It consists of 12 items assessing three subscales that sequentially explore ocular irritation, impact on vision-related functioning and the environmental triggers of dry eyes. Moreover, the OSDI possesses the psychometric properties necessary for it to be used as an end point in clinical settings.[9]

In addition to causing ocular discomfort, DED may also affect the quality of life of an individual substantially by decreasing his or her visual functioning.[10-11] Individuals with dry eye symptoms exhibit large optical aberrations which may reduce the optical quality of their eye.[11] This includes contrast sensitivity, which is the human ability to visualise an object in different contrasts, sizes and shapes,[12, 13] thus affecting their daily lives. For example, the visibility of a car on the road differs between a rainy and a bright, sunny day, and this may affect the driving abilities of an individual.

In addition to the questions examining the symptoms of dry eyes, the OSDI also includes four items (questions) that explore the vision-related functioning of the eyes, thus enabling inclusion of visual function factors in the final OSDI score.

Several studies have reported a reduction in contrast sensitivity among patients with diabetes.[14-16] Therefore, this study utilizes the OSDI to identify the predictors of dry eye symptoms in a diabetic population.

Methods

This cross-sectional, single-visit study was registered under the National Medical Research Registry (NMRR) and was conducted in accordance with the ethical standards of the Helsinki Declaration. It was approved by the Medical Research Ethics Committee, MREC and the IIUM Ethics Research Committee, IREC.

Sample size. This study was conducted between the 19th of September and the 15th of December 2016. The sample size required was calculated using the PS Software, in accordance with previous studies.[17]

Inclusion and Exclusion Criteria. This study included patients diagnosed with diabetes and followed up in diabetic clinical settings, and controls who did not have a diagnosis of diabetes and exhibited random blood glucose levels of 6% or lower. All individuals (both patients and controls) included in this study were between 19 and 39 years of age.

Those with additional health issues other than diabetes, including severe dry eyes, cataract, ocular surface disorders, colour vision defects, untreated squint and pregnancy were excluded from the study. The diabetic patients were selected from the Tengku Ampuan Afzan Hospital in Kuantan and the Kemaman Hospital, and their names, contact numbers, addresses and Hba1cs were extracted from the hospital records. Informed consent was collected telephonically from those who met the inclusion criteria. The controls were selected via advertisement.

Data Collection. All participants were invited to the Department of Optometry and Visual Science, International Islamic University Malaysia, Kuantan, Pahang, where data collection was conducted.

Procedures. The data recorded included the age, sex, occupation, duration of the condition, stage of progression of the disease and existence of any associated conditions. The ocular examination included tests for contrast sensitivity (wall mounted Pelli-Robson chart), visual acuity (LogMar chart), colour vision (FM 100 Hue), tear volume (Phenol Red Thread), TBUT (tear break up time), fluorescein corneal staining, Marx's line displacement, meibomian gland count and meibomian secretion quality. The participants were then asked to complete an OSDI questionnaire that had been validated in Bahasa Malaysia[18] to record the dry eye ocular symptoms (OSDI score) experienced.The ocular media of each subject was examined using a slit lamp to allow differentiation from any underlying conditions such as cataract, corneal ulcers or other ocular diseases. The random blood glucose level was recorded using a finger prick test at the end of a session to confirm which group the participant belonged.

Results

The results of this study showed that all of the contrast sensitivity variables were normal, and the range of the contrast sensitivity score in the control group was in agreement with that suggested by Pelli-Robson (1.65–1.95) for a monocular test conducted among individuals belonging to the same age group as that of the current study.[19] The contrast sensitivity in the right eye differed between the diabetic patients and the controls (Table 1), and a Mann–Whitney test confirmed that this difference was statistically significant ($p = 0.045$). The diabetic patients exhibited a lower mean score in log units for contrast sensitivity compared with the controls. However, no such differences in contrast sensitivity were observed in the left eye and binocular vision between the patient and control groups.

Table 1. Median (Range) and Normative Value of Contrast Sensitivity and Visual Acuity

Parameter (unit)	Patients with diabetes (n = 37)	Controls (n = 37)	All Subjects (n = 74)	Normative value	Difference between groups
	Median (range)				*p*
CS_RE (log)	1.95 (1.65–1.95)	1.95 (1.65–1.95)	1.95 (1.65–1.95)	1.65–1.95[18]	**0.045**
CS_LE (log)	1.95 (0.30–1.95)	1.95 (1.65–1.95)	1.95 (0.30–1.95)		0.252
VA_RE (LogMar)	−0.1 (-0.30-0.86)	−0.1 (-0.30–0.04)	−0.1 (−0.30–0.86)	0.0 LogMar	0.492
VA_LE (LogMar)	−0.1 (−0.30–1.80)	−0.1 (−0.28–0.10)	−0.1 (−0.30–1.80)		0.498

Mann–Whitney test
Statistically significant differences are shown in bold.
CS: contrast sensitivity; VA: visual acuity; RE: right eye; LE: left eye.

Univariate analysis of the patient data showed that the ocular symptoms (OSDI score) were associated with visual acuity, contrast sensitivity, colour vision, PRT, TBUT, corneal staining, Marx's line displacement, meibomian gland counts and meibomian secretion quality (Table 2). The visual acuity and contrast sensitivity in each eye were significantly associated with the OSDI score (Figure 1 to 4). However, no significant associations between OSDI scores and other parameters were observed.

Table 2. The Correlation Coefficients (r) and p-values of the Associations between OSDI Score, Visual Functions and Clinical Signs in the Right Eye

Parameter	OSDI score	
	Correlation Coefficient, (Spearman rho)	*p*
Visual Acuity	0.330	0.046
Contrast Sensitivity	−0.454	0.005
Total Error Score of FM 100 Hues	0.261	0.118
PRT	−0.312	0.060
TBUT	−0.295	0.077
Corneal Staining	−0.011	0.950
Marx's Line Displacement	−0.017	0.922
Meibomian Glands count	−0.072	0.671
Meibomian Gland Secretion Quality	0.212	0.209

Figures shown in bold represent significance levels of $p < 0.05$, whereas figures shown in italics represent significance levels of $0.05 < p < 0.25$. TBUT: tear break up time test; PRT: phenol red thread

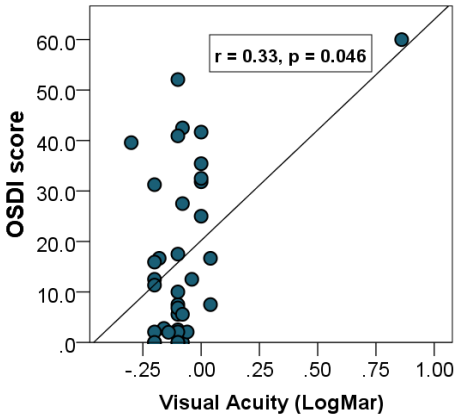

Figure 1. Association between Visual Acuity and OSDI Score in the Right Eye of Patients with Diabetes (n = 37)

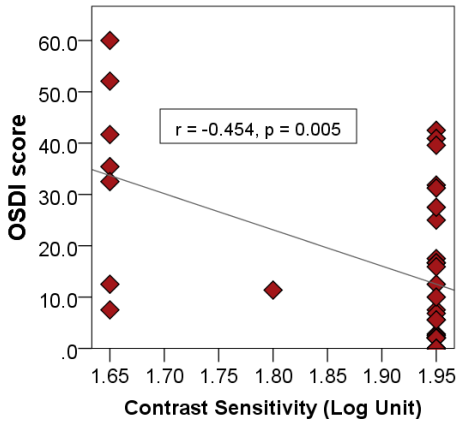

Figure 3. Association between Contrast Sensitivity and OSDI Score in the Right Eye of Patients with Diabetes (n = 37)

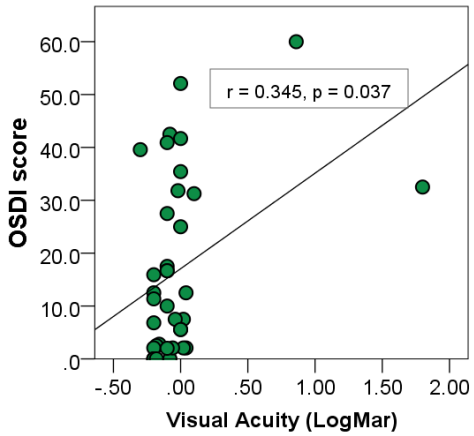

Figure 2. Association between Visual Acuity and OSDI Scoare in the Left Eye of Patients with Diabetes (n = 37)

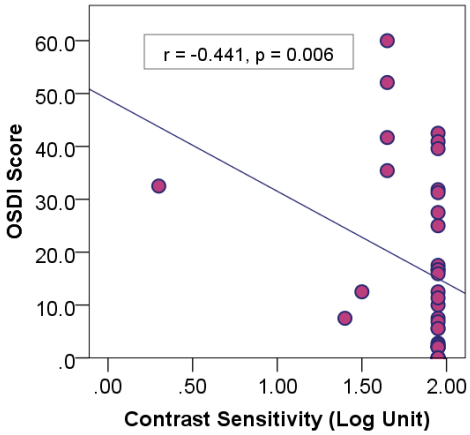

Figure 4. Association between Contrast Sensitivity and OSDI Score in the Left eye of Patients with diabetes (n = 37)

Table 3. Multivariate Analysis of Ocular Surface Symptoms in the Right Eye of Patients with Diabetes (n = 37)

Dependent parameter	OSDI	
Significant univariate relationships at $p < 0.25$	Visual Acuity	
	Contrast Sensitivity	
	Total Error Score of 100 Hue	
	Tear Volume (PRT)	
	TBUT	
	Meibomian Gland Secretion Quality	
Independent parameters in the final model	Unstandardised Coefficients β	*p*
	164.786 Constant	0.004
	19.504 Visual Acuity	0.234
	−69.706 Contrast Sensitivity	0.010
	−0.036 Total Error Score of 100 Hue	0.436
	−0.553 Tear Volume (PRT)	0.099
	−0.333 TBUT	0.338
	−1.171 Meibomian Gland Secretion Quality	0.849
R^2%	33.90%	
p	0.004	
Predictor/s	−69.71Contrast Sensitivity	
Equation	OSDI = −69.71 Contrast Sensitivity + 164.786	

Non-standardised coefficients that were statistically significant ($p < 0.05$) have been shown in bold.

Significant univariate relationships were observed between the OSDI score and visual acuity, contrast sensitivity, total error score of FM 100 Hue, tear volume (PRT), TBUT and meibomian gland secretion quality. The variables were then selected based on the statistical significance of their associations with the OSDI score ($p < 0.25$) and included in a model for univariate analysis.

The final model, which contained all of the initial independent variables (Table 3), explained 33.9% of the variance in OSDI observed, and this was statistically significant ($p = 0.002$). Therefore, after controlling for all other variables in the model, a lower contrast sensitivity value was seen to be associated with a higher OSDI score (more symptoms). The model predicted that 0.1 unit decrease in contrast sensitivity would be associated with an increase of 6.97 units in the OSDI score.

Discussion

The results of this study showed that the contrast sensitivity significantly differed between patients with diabetes and the controls. As expected, the former exhibited a lower mean score in log units compared with the latter, even though the contrast sensitivity was within the normal range in all participants. No significant differences in visual acuity were observed.

The univariate analysis demonstrated a positive association between OSDI score and visual acuity and contrast sensitivity, with higher scores being associated with higher levels of visual acuity (poorer vision) and lower levels of contrast sensitivity (poorer contrast). However, no significant association between OSDI score and any of the other parameters was observed.

The multivariate analysis showed that contrast sensitivity was a predictor of the OSDI score. Although visual acuity was also included in the final model, the results showed that it was not a predictor of symptoms in the presence of other independent variables. Therefore, the results of this study showed that diabetes had a significant effect on visual function (contrast sensitivity), and contrast sensitivity may be considered as a predictor of ocular symptoms in patients with early stages of the disease.

In the current study, the contrast sensitivity in the right eye was significantly lower in patients with diabetes compared with the controls. However, no such difference was observed in the left eye. This was in agreement with a study examining contrast sensitivity and visual acuity in driving, reported that difficulties caused by the impairment of contrast sensitivity were a condition-dependent scenario.[20] However, it is difficult to isolate and assess contrast sensitivity without confounding by other factors. Previous study stated that despite ideal visual acuity, image formation (contrast) would still be limited to a certain extent due to diffraction at the pupil.[21] So, as contrast sensitivity is related to visual acuity,[20] we speculate that the result of contrast sensitivity was potentially influen-ced by the visual acuity and other visual function which were not significantly different between the groups.

The majority of the patients with diabetes included in this study were not present with any signs of retinopathy or ocular symptoms. Three of the patients exhibited mild to moderate non-proliferative diabetic retinopathy, whereas two of them presented with proliferative retinopathy. However, this study proved that diabetes may present symptoms in visual function prior to the signs of complication. Contrast sensitivity greatly affects the quality of vision of an individual and is superior to visual acuity in daily life situations.[13] Therefore, patients with diabetes are encouraged to take extra precaution and include contrast sensitivity in their routine diabetic check-up, irrespective of whether they present with or without retinopathy.

Conclusions

The results of this study were in agreement with the majority of previous evidence examining the effects of diabetes on contrast sensitivity.[15,16] In conclusion, contrast sensitivity differed sigificantly between young adult patients with diabetes and controls, and this could be used to predict ocular dry eye disease symptoms in patients.

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Conflict of Interest Statement

The authors declare that they have no conflicts of interest with regard to this study.

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