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A Study of Contrast Sensitivity Evaluation in Young Adults and Elderly People With and Without Diabetes Mellitus

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Abstract:

Background: *Diabetes mellitus (DM) is a global major pathology that affects macro and microvascular systems with associated ocular complications, in which reduced contrast sensitivity (CS) is compromised. Additionally, CS declines with aging. There is no available data in the literature about the association between age and contrast sensitivity so far in Palestine.*

Objectives*: The aims of this study were to determine the associations between contrast sensitivity and age; and gender, and compare the contrast sensitivity between diabetic and non-diabetic subjects.*

Methods*: A prospective study was performed using a case-controlled study based on the assessment of subjects attending the Optometry Department, Faculty of Health Sciences, Islamic University-Gaza. The functional acuity contrast test (FACT) was used to estimate the contrast sensitivity in eyes of normal and abnormal subjects. In this study, the data of 135 subjects were collected in a period between December 2017 and June 2017 by using a convenience sampling method. Statistical analysis was conducted using Spearman rank in non-parametric data between contrast sensitivity and each variable (IBM SPSS Version 20).*

Results: *There was a negative association between contrast sensitivity and age for male and female subjects (r=-0.60, p<0.001; r=-0.45, p<0.001) respectively. Male subjects ≥ 50 years had higher scores of contrast sensitivity compared to female subjects ≥ 50 years (r=-0.34, p=0.008). However, no significant association was found between male subjects < 50 years compared to female subjects < 50 years (r=-0.10, p=0.43). Diabetic subjects had a lower value of contrast sensitivity compared to non-diabetic* *subjects. However, no significant association was found between both groups (r=-0.25, p=0.19).*

Conclusion: *Age-wise, both males and females subjects who are 50 years old and above had a lower contrast sensitivity values than younger subjects. Contrast sensitivity was also found to be higher in males ≥ 50 years old compared to their counterpart females. Diabetes was not found to have an association with the change of contrast sensitivity.*

Keywords: Contrast sensitivity; functional acuity contrast test; univariate analysis; diabetics; normal subjects; prospective analysis

Introduction

Contrast sensitivity (CS) is an essential aspect of vision (Haymes et al., 2006). The CS is also commonly known as a function of spatial frequency (Allard, Renaud, Molinatti, & Faubert, 2013) . Earlier studies have shown contrast sensitivity to be measured by determining the minimum contrast level required to detect stimuli of varied frequencies (Nio et al., 2000);(Karas & McKendrick, 2009). According to Oshika et al. 2006, CS is the visual ability to distinguish shades of grey from each other or from their background, while colour contrast sensitivity is the ability to discriminate varying shades of colour – for example light blue from a darker blue. Studies conducted by (Mäntyjärvi & Laitinen, 2001) and others, (Nio et al., 2000) ; (Karas & McKendrick, 2009); (Allard et al., 2013) assessed contrast sensitivity to different spatial frequencies, in addition to visual acuity. Clinical studies found that the overall picture which emerges is that age differentially affects contrast sensitivities of different spatial frequencies, with low spatial frequencies affected the least, and high spatial frequencies the most. This pattern appears to be evident even when older cases have good visual acuity values between 6/9-6/6 (Chung & Legge, 2016). Numerous studies demonstrated that contrast sensitivity declines with normal aging (Liutkevičiene, Čebatoriene, Liutkevičiene, Jašinskas, & Žaliuniene, 2013);(Owsley, 2011). This might be due to a variety of reasons broadly categorized into optical (Liutkevičiene et al., 2013);(Owsley, Sekuler, & Siemsen, 1983) and neural (Elliott, Whitaker, & MacVeigh, 1990);(Burton, Owsley, & Sloane, 1993) . Optical effects are caused by senile miosis, increased lenticular light scatter, and ocular aberrations due to reduced retinal illuminance. Sloane et al estimated that a 20-yr-old eye transmits approximately three times of the amount of light as a 60-yr-old eye.

Most studies found that a decrease in retinal illuminance caused by a decrease in CS at high spatial frequencies. In an earlier studies, Spear found that neural changes contribute to the decrease of contrast sensitivity with aging. This condition is caused by various physiological changes that occur at different levels of the visual system. Previous study found that linear reduction in neuron density in the cortex between the ages of 20 and 87 yrs. A large number of various clinical studies of CS have revealed abnormalities in patients with diabetes mellitus (DM), corneal edema, cataract, retinal disease, optic neuritis, amblyopia, and glaucoma (Freedman & Thibos, 1975)˒(Regan & Neima, 1984). DM has become a major public health concern in recent time (Aljarousha, Badarudin, & Che Azemin, 2016). The global prevalence of diabetes is estimated to be 246 million in 2007 and would possibly reach up to 380 million by 2025 (Abd Rahman, Badarudin, Che Azemin, Ahmad, & Arifin, 2018). Samuel et al. found that contrast sensitivity testing may be useful in detecting the early effects of diabetic retinopathy (DR) on neural activity since visual acuity is often normal. In Palestine, there is no available data in the literature about the association between age and contrast sensitivity. Only very few recent published articles showed the change of contrast sensitivity with aging in the Middle East (Hashemi et al., 2012). The current study is the first to look at the decline of CS with aging in Gaza Strip, Palestine. The results of this investigation may serve to inform the eye-care community and may assist clinicians in advising and managing their patients more suitably. Also, the results of this study may enhance the understanding of the relationship between CS and DM.

Methodology

Data collection

A prospective study was performed using a case-controlled study based on the assessment of subjects attending the Optometry Department, Faculty of Health Sciences, Islamic University -Gaza (IUG). The study protocol has been approved by local ethics committee from Ministry of Health. In this study, 135 adult participants were examined from March to June 2017 by using a convenience sampling method. The appropriate sample size was determined by using the PS Software. Subjects were divided into three groups according to age (< 50 vs. ≥ 50-yrs old males), (< 50 vs. ≥ 50-

yrs old females); gender (< 50 yrs males vs. < 50 yrs females), (≥ 50 yrs males vs. ≥ 50 yrs females) and diabetes mellitus (diabetic vs. non-diabetic subjects). All subjects had visual acuity values between 6/9-6/7.5. History of any previously confirmed systemic diagnosis of diabetes by a specialist was recorded (self-reported). Patients who had ocular surgeries or laser treatment, contact lens wear, rheumatoid arthritis, Sjogren's syndrome and those who are taking any forms of the medication such as antihistamines, tricyclic antidepressants, oral contraceptives, drugs used to treat high blood pressure and diuretics were excluded from the study. Functional acuity contrast test (FACT) is a non-invasive method of assessing contrast sensitivity in the eyes of normal and abnormal subjects (Nomura, Ando, Niino, Shimokata, & Miyake, 2003). This test comprises of a chart with sine-wave gratings of varying frequencies. The chart tests five spatial frequencies (sizes) and nine levels of contrast. The spatial frequencies vary down the columns from top to bottom and the FACT varies in row and decreases from left to right. The technique was performed at a distance of 10 feet. Participants were reported the orientation of the grating: right, left or up and the last determined grating seen for A, B, C and D rows was considered and it was plotted on a contrast sensitivity curve.

Statistical analysis

Data analysis was done using IBM SPSS (Version 20.0, SPSS Inc, Chicago, Illinois, USA). Non-parametric McNemar's test was used for data analysis. In this study, Spearman rank was used to evaluate associations between contrast sensitivity and each of the independent variables. The independent variables were age (< 50 vs. ≥ 50-yrs old males), (< 50 vs. ≥ 50-yrs old females); gender (< 50 yrs males vs. < 50 yrs females), (≥ 50 yrs males vs. ≥ 50 yrs females) and DM (diabetic vs. non-diabetic subjects). With significance was calculated at CI 95% and error 0.05

Results

Fifteen self-reported DM patients were identified from a total of 135 subjects (7 males and 8 females) with a mean ± standard deviation of 53 ± 7.9 years. For the purpose of comparison, 15 non-diabetic, age and gender-matched subjects were chosen from the same patient pool: 7 males and 8 females with a mean ± standard deviation of 56 ± 5.1

years. There were no significant differences in matched or other unmatched characteristics between diabetic and non-diabetic subjects (Table 1).

Table 1: Subjects' characteristics

	Diabetic subjects (N=15, 30 eyes)	Non-diabetic subjects (N=15, 30 eyes)	p-value
Mean age, years (SD)	53 ± 7.9	56 ± 5.1	0.919
Male (%) Female (%)	7 (46.7) 8 (53.3)	7 (46.7) 8 (53.3)	0.796

SD: standard deviation; N: number; %: percent
McNemar's test

Contrast sensitivity was negatively associated with age both in males and females (for males r=-0.60, p<0.001 and for females r=-0.45, p<0.001) in the right and left eyes as shown in figure 1 and 2. Males ≥ 50 yrs old were also found to have higher contrast sensitivity than their females counterpart (r=-0.34, p=0.008) as shown in figure 3. There was no significant association between diabetes and contrast sensitivity in all groups studied. The values of correlation (r) in the left eye were -0.18, -0.62, -0.45, -0.37, and -0.26 for males and females < 50 years old, 50 < male subjects ≥ 50 years old, 50 < female subjects ≥ 50 years old, females ≥ 50 yrs vs. males ≥ 50 yrs and diabetic respectively.

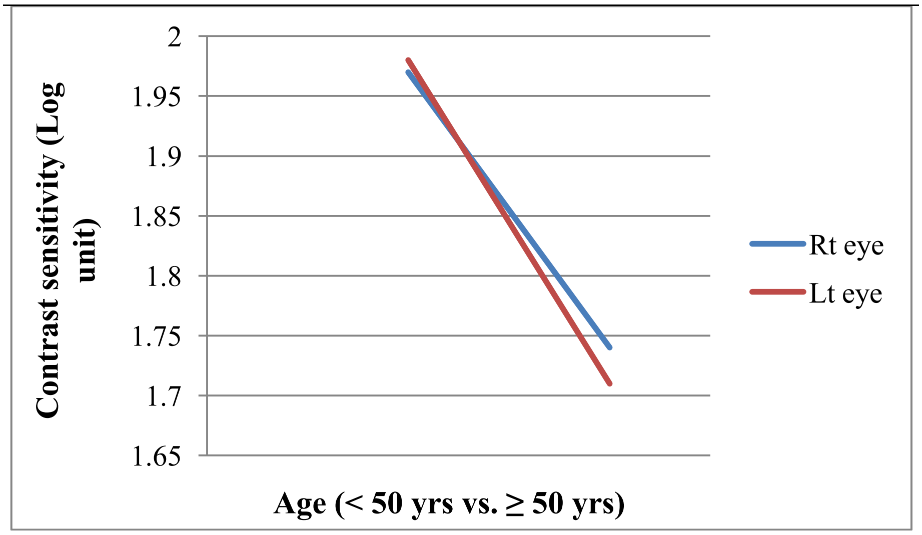

Figure 1: Negatively association between contrast sensitivity and age (< 50 yrs vs. ≥ 50 yrs) in male subjects in the right and left eyes (n= 120, p<0.001)

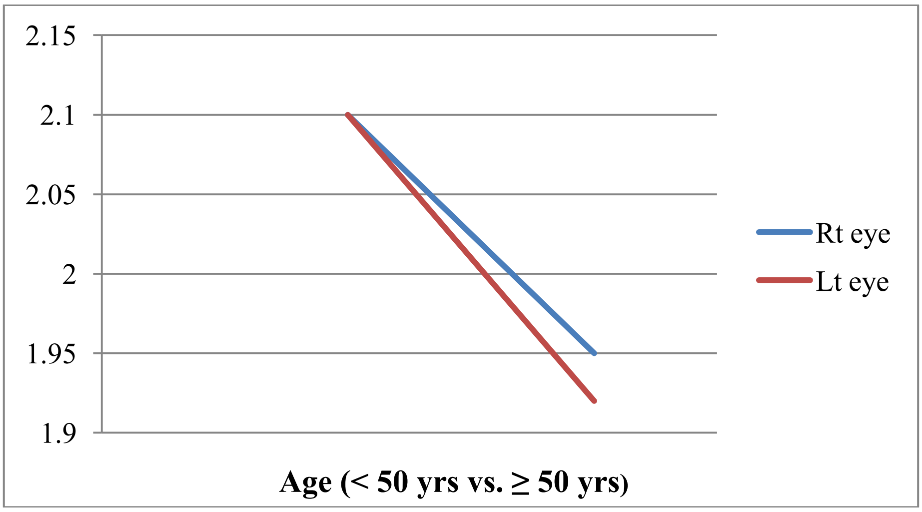

Figure 2: Negatively association between contrast sensitivity and age (< 50 yrs vs. ≥ 50 yrs) in female subjects in the right and left eyes (n= 120, p<0.001)

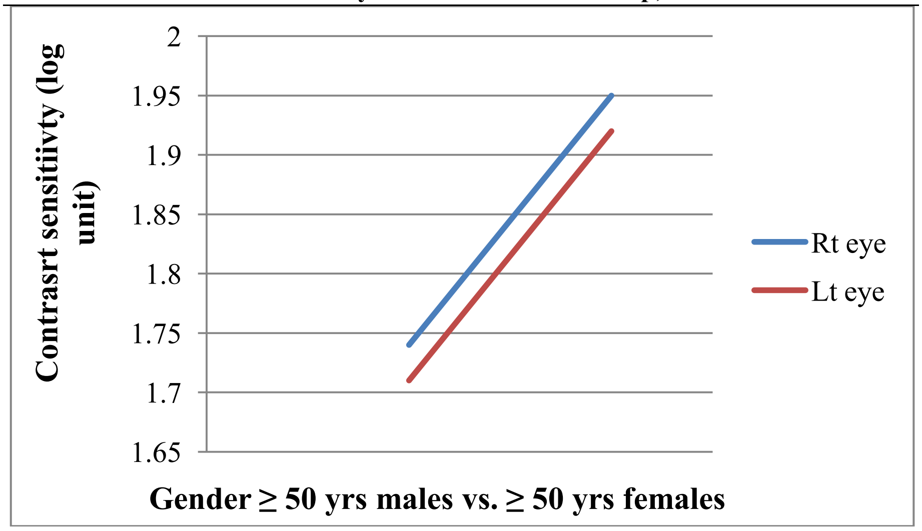

Figure 3: Negatively association between contrast sensitivity and ≥ 50 yrs males vs. ≥ 50 yrs females in the right and left eyes eye (n=120, p=0.008)

Discussion

In the current study, there was a significant association between contrast sensitivity and age for male and female subjects. The reason for our finding might be because senile miosis, increased lenticular light scatter, and ocular aberrations are due to reduced retinal illuminance (Hashemi et al., 2012). Besides, previous studies had also reported that neural changes contribute to the decrease of contrast sensitivity with aging (Elliott et al., 1990)ˉ(Spear, 1993). This result is consistent with earlier studies(Allard et al., 2013)'(Liutkevičiene et al., 2013)'(Owsley, 2011). We found male subjects ≥ 50 yrs had higher scores of contrast sensitivity compared to female subjects ≥ 50 yrs. This is consistent with a previous experimental study found lower subjective contrast sensitivity in female rats(van Alphen, Winkelman, & Frens, 2009). This result was also corroborated by a more recent study from Iran (Hashemi et al., 2012). However, no significant association was found between the < 50 yrs males vs. < 50 yrs females and contrast sensitivity in the present study. Solberg and Brown also reported that there was no correlation between gender and contrast sensitivity. Diabetic subjects in this study had a lower value of contrast sensitivity compared to non-diabetic subjects. However, no significant association was found between both groups. This might be due to the information about the types of DM [insulin-dependent diabetes mellitus (IDDM, type 1)] and (Non-IDDM, type 2) and the three stages of diabetic nephropathy (DR) [background DR, pre-proliferative DR and proliferative DR] were not available in the current study. This is a limitation of the study. In contrast, many studies have reported significantly decreased contrast sensitivity in diabetic subjects (Regan & Neima, 1984)(Abd Rahman et al., 2018).

Conclusion

It can be concluded that both males and females subjects who are 50 years old and above had a lower contrast sensitivity values than younger subjects. Contrast sensitivity was also found to be associated with ≥ 50 yrs males vs. ≥ 50 yrs females in the right and left eyes. Several factors such as < 50 yrs males vs. < 50 yrs females and diabetes mellitus were not associated with contrast sensitivity in both eyes.

List of abbreviations (if any)

CS: Contrast sensitivity; FACT: functional acuity contrast test; DM: diabetes mellitus; DR: diabetic retinopathy; IDDM, type 1: insulin-dependent diabetes mellitus; Non-IDDM, type 2: Non-insulin-dependent diabetes mellitus.

IRB permissions:

This study was approved by local ethics committee from Ministry of Health.

Competing interest

None to declare

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Conflict of interest

None to declare

References

1- Abd Rahman, A. A., Badarudin, N. E., Che Azemin, M. Z., Ahmad, N., & Arifin, A. E. (2018). Changes in Contrast Sensitivity in Young Adults with Diabetes. Makara Journal of Health Research, 22(1). http://doi.org/10.7454/msk.v22i1.8735

2- Aljarousha, M., Badarudin, N. E., & Che Azemin, M. Z. (2016). Comparison of dry eye parameters between diabetics and non-diabetics in district of Kuantan, Pahang. Malaysian Journal of Medical Sciences, 23(3), 72–77.

3- Allard, R., Renaud, J., Molinatti, S., & Faubert, J. (2013). Contrast sensitivity, healthy aging and noise. Vision Research, 92, 47–52. http://doi.org/10.1016/j.visres.2013.09.004

4- Burton, K. B., Owsley, C., & Sloane, M. E. (1993). Aging and neural spatial contrast sensitivity: Photopic vision. Vision Research, 33(7), 939–946. http://doi.org/10.1016/0042-6989(93)90077-A

5- Chung, S. T. L., & Legge, G. E. (2016). Comparing the shape of contrast sensitivity functions for normal and low vision. Investigative Ophthalmology and Visual Science, 57(1), 198–207. http://doi.org/10.1167/iovs.15-18084

6- Elliott, D., Whitaker, D., & MacVeigh, D. (1990). Neural contribution to spatiotemporal contrast sensitivity decline in healthy ageing eyes. Vision Research, 30(4), 541–547. http://doi.org/10.1016/0042-6989(90)90066-T

7- Freedman, R. D., & Thibos, L. N. (1975). Contrast sensitivity in humans with abnormal visual experience. The Journal of Physiology, 247(3), 687–710. http://doi.org/10.1113/jphysiol.1975.sp010952

8- Hashemi, H., Khabazkhoob, M., Jafarzadehpur, E., Emamian, M. H., Shariati, M., & Fotouhi, A. (2012). Contrast sensitivity evaluation in a population-based study in Shahroud, Iran. Ophthalmology, 119(3), 541–546. http://doi.org/10.1016/j.ophtha.2011.08.030

9- Haymes, S. A., Roberts, K. F., Cruess, A. F., Nicolela, M. T., LeBlanc, R. P., Ramsey, M. S., … Artes, P. H. (2006). The Letter Contrast Sensitivity Test: Clinical Evaluation of a New Design. Investigative Opthalmology & Visual Science, 47(6), 2739. http://doi.org/10.1167/iovs.05-1419

10- Karas, R., & McKendrick, A. M. (2009). Aging alters surround modulation of perceived contrast. Journal of Vision, 9(5), 11.1-9. http://doi.org/10.1167/9.5.11

11- Liutkevičiene, R., Čebatoriene, D., Liutkevičiene, G., Jašinskas, V., & Žaliuniene, D. (2013). Associations between contrast sensitivity and aging. Medicina (Lithuania), 49(6), 273–277.

12- Mäntyjärvi, M., & Laitinen, T. (2001). Normal values for the Pelli-

Robson constrast sensitivity test. J Cataract Refract Surg, 27(2), 261–6. http://doi.org/10.1016/S0886-3350(00)00562-9

13- Nio, Y. K., Jansonius, N. M., Fidler, V., Geraghty, E., Norrby, S., & Kooijman, A. C. (2000). Age-related changes of defocus-specific contrast sensitivity in healthy subjects. Ophthalmic and Physiological Optics, 20(4), 323–334. http://doi.org/10.1016/S0275-5408(99)00103-9

14- Nomura, H., Ando, F., Niino, N., Shimokata, H., & Miyake, Y. (2003). Age-related change in contrast sensitivity among Japanese adults. Japanese Journal of Ophthalmology, 47(3), 299–303. http://doi.org/10.1016/S0021-5155(03)00011-X

15- Oshika, T., Okamoto, C., Samejima, T., Tokunaga, T., & Miyata, K. (2006). Contrast Sensitivity Function and Ocular Higher-Order Wavefront Aberrations in Normal Human Eyes. Ophthalmology, 113(10), 1807–1812. http://doi.org/10.1016/j.ophtha.2006.03.061

16- Owsley, C. (2011). Aging and vision. Vision Research. http://doi.org/10.1016/j.visres.2010.10.020

17- Owsley, C., Sekuler, R., & Siemsen, D. (1983). Contrast sensitivity throughout adulthood. Vision Research, 23(7), 689–699. http://doi.org/10.1016/0042-6989(83)90210-9

18- Regan, D., & Neima, D. (1984). Low-contrast letter charts in early diabetic retinopathy, ocular hypertension, glaucoma, and Parkinson's disease. British Journal of Ophthalmology, 68(12), 885–889. http://doi.org/10.1136/bjo.68.12.885

19- Sloane, M. E., Owsley, C., & Alvarez, S. L. (1988). Aging, senile miosis and spatial contrast sensitivity at low luminance. Vision Research, 28(11), 1235–1246. http://doi.org/10.1016/0042-6989(88)90039-9

20- Sokol, S., Moskowitz, A., Skarf, B., Evans, R., Molitch, M., & Senior, B. (1985). Contrast Sensitivity in Diabetics with and Without Background Retinopathy. Archives of Ophthalmology, 103(1), 51–54. http://doi.org/10.1001/archopht.1985.01050010055018

21- Solberg, J. L., & Brown, J. M. (2002). No Sex Differences in Contrast Sensitivity and Reaction Time to Spatial Frequency. Perceptual and Motor Skills, 94(3), 1053–1055. http://doi.org/10.2466/pms.2002.94.3.1053

22- Spear, P. D. (1993). Neural bases of visual deficits during aging. Vision Research. http://doi.org/10.1016/0042-6989(93)90218-L

23- van Alphen, B., Winkelman, B. H. J., & Frens, M. A. (2009). Age- and Sex-Related Differences in Contrast Sensitivity in C57Bl/6 Mice. Investigative Opthalmology & Visual Science, 50(5), 2451. http://doi.org/10.1167/iovs.08-2594