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The macular photostress test in diabetes, glaucoma and cataract

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ABSTRACT

Purpose. The photostress recovery time test (PSRT) has been widely reported as a helpful screening clinical tool. However, the poor standardization of its measurement technique remains to be a limitation among clinicians. The purpose of this study is to apply a recommended clinical technique to measure the PSRT in some of the most common eye diseases to ascertain whether these diseases affect the PSRT values.

Methods. One hundred and one controls and 105 patients, with diagnosed diabetes (without visible signs of diabetic retinopathy), primary open angle glaucoma (POAG) or cataracts underwent photostress testing. The test was performed with a direct ophthalmoscope for illuminating the macula for 30 seconds. Participants belonged to three age classes: A, B and C; and were divided into four groups: control, diabetic, POAG and cataract. The age range for A, B and C classes were respectively 43-54, 55-64 and 65-74 years. The groups were also further compared within each age class. In addition, the influence of age on PSRT was evaluated using the control group.

Results. Results demonstrate that PSRT changes with age ($p < 0.02$). In class A, diabetic group had a faster PSRT than control group, (mean $\pm$ standard deviation) 20.22 ± 7.51 and 26.14 ± 8.34 seconds. The difference between these groups was statistically significant (t-test, $p = 0.012$). Cataract and POAG groups did not affect the PSRT significantly.

Conclusions. The technique used for the Photostress showed that diabetics, younger than 54 years, may have faster PSRT and that, aging delays PSRT.

Keywords: Macular, photostress, glare recovery, glaucoma, diabetes, cataract

1. INTRODUCTION

When the eye is exposed to an intense light the chemical balance of the retinal cells is disturbed. The time it takes for retina to recover can be used to test retinal function otherwise known as the photostress test. Photostress recovery time (PSRT) is the period of time required for the macula to return to its normal level of function after being exposed to an intense light source. PSRT is dependent on the speed of regeneration of the photopigments after being bleached and this regeneration occurs normally when retinal metabolic processes or connections between the retinal pigment epithelium and photoreceptors are intact.¹

PSRT can be affected by several factors such as aging, eye diseases and drugs.²⁻⁵ The effect of aging on PSRT is still under discussion since some studies found increased PSRT with age² whilst, others did not find any significant effect.⁶ Despite the differences in their underlying causes, changes in PSRT caused by eye diseases such as cataracts, glaucoma and diabetic retinopathy (DR) have been studied at length.^{4, 6, 7} Diabetic retinopathy affects the microvasculature of the inner retina⁸ and causes neurodegeneration, that may occur independent of microvasculature changes.⁹ Several studies reported that PSRT is elevated in people with diabetes.^{10, 11} Elevated PSRT has also been found in primary open angle glaucoma (POAG) which is characterized by progressive death of the retinal ganglion cells.^{4, 12, 13} Age-related cataracts, causing cloudy or opaque areas in the eye lens, do not cause significant PSRT changes as long as sufficient bleaching light can reach the retina.¹⁴

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The main limitation of the PSRT, as a screening tool for various eye diseases, is the poor standardization of its measurement technique. In a normal clinical setting PSRT can be obtained by, after a period of dark adaptation, measuring the time that a person takes to recover to a maximum difference of one line from its initial acuity after being exposed to a bright light.¹⁵ Pen torches and direct ophthalmoscopes have been suggested as light sources to induce photostress. More elaborated photostress techniques have been proposed including Maxwellian view optical systems, scanning laser ophthalmoscopes, visually evoked potentials and more recently a commercially available instrument Eger Macular Stressometer test.^{2, 6, 16, 17} However, the percentage of bleached photopigments vary depending on the retinal illuminance produced by the particular instrument as it may happen even with the length of light exposure of the same instrument which is critical for an accurate PSRT testing.² The lack of standardization of retinal illumination limits the comparison capability between studies and may force clinicians to set their own standards.

Despite the pointed limitation, the photostress test remains to be a helpful screening tool. Some additional points about the photostress test are that it is safe, short in duration of the procedure, noninvasive as well as inexpensive. Therefore, we believe that more studies are warranted to insure a better understanding and standardization of the test. In this study we measured PSRT in people with glaucoma, diabetes and cataracts to ascertain whether these conditions affect the PSRT values. Measurements were performed according to the best clinical technique establish by Margrain and Thomson.²

2. METHODS

2.1 Participants

Patients: one hundred and five patients attending an eye clinic, with diagnosed diabetes, POAG or cataracts participated in this study; from each patient one of the eyes was randomly pre-selected (sortition). Participants were recruited consecutively over 1-year period, ranging in age from 43 to 74 years, corrected acuity no less than 1.0 (decimal scale) in both eyes with an exception of cataract patients. Inclusion criteria: diabetes group, no systemic diseases other than diabetes or juvenile forms of diabetes, non-insulin dependent, with no visual signs of DR and no other known ocular disease; POAG group, no ocular diseases other than POAG, with no ocular surgery, reproducible and reliable visual field defects (HFA II, Carl Zeiss Meditec, Dublin, CA); cataract group: no ocular diseases other than cataracts.

Controls: one hundred and one controls were selected from people attending the same clinic for refraction; again, one eye, at random, from each patient was measured. Inclusion criteria were: age range 43 to 74 years, with no ocular or systemic diseases and corrected acuity no less than 1.0 in each eye. Exclusion criteria were: refractive errors >3D (positive or negative) or astigmatism >1.5D, fixation or behavioral problems and ptosis.

The study conformed with the tenets of Declaration of Helsinki with an informed consent obtained from all participants.

2.2 Instruments

The direct ophthalmoscope (Welch Allyn, Ref 11735) luminous intensity was evaluated (MINOLTA T-10, MINOLTA CO., Ltd, Japan) three times during the period of the study. The luminous intensity (adjust to full intensity) of the direct ophthalmoscope (macular spot) was, mean $\pm$ standard deviation (SD), 10.9 ± 0.6 candela.

2.3 Procedure

The photostress test was administered to each patient and control by an experienced examiner according to the procedure described by Margrain and Thomson for photostress test using a direct ophthalmoscope with full charge.² The macular spot of a direct ophthalmoscope (adjusted to full intensity) was projected directly onto the macula for 30 seconds. The ophthalmoscope was held as close to the eye as possible and fixation was confirmed visually by the examiner. After this procedure the time taken for acuity to return within one line of pre-bleach was measured. Pupil size was not measured and eyes were undilated.

2.4 Statistical Analyses

Participants were divided into groups by condition (controls, diabetics, POAG and cataracts groups) and age (A, B and C classes). The age range in class A was 43-54 years, class B 55-64 years and class C 65-74 years. The adopted class division was similar to other ophthalmologic studies found in the literature.¹⁸ Groups with less than 6 participants were excluded from further analysis because they were not representative of the population.

PSRT data obtained from control, diabetic, POAG and cataract groups were compared within each age group. The Bartlett's test was utilized to study the homogeneity of variances, and the ANOVA (one-way) test for unequal variances (Welch) and ANOVA (one-way) for equal variance were utilized, respectively for B and C age groups. The t-test was used for comparisons of class A, because the only available data were from control and diabetic groups, and for comparing the right and left eyes of each age group. To make it easier to compare this study to other studies,⁴ t-test was used in class B for the control and POAG groups. Data were analyzed using the statistical package SPSS 19.0 (SPSS Inc, Chicago, IL, USA) and GraphPad Prism 5.03 (GraphPad Software Inc, San Diego, CA, USA).

3. RESULTS

Control results, shown in Figure 1, were used to study the effect of age on PSRT using a linear regression model² $PSRT = 11.51 + 0.29 \times \text{age}$. The relationship between age and PSRT (Figure 1) was significant at the 0.02 level (df=99, F=6.03).

The mean PSRT value was not statistically different for right and left eyes.

All results displayed in Table 1.

Figure 1. Scatter diagram showing PSRT plotted against age. The least square linear regression line (straight line) and the 95% confidence intervals (dash lines) are shown. The relationship between age and PSRT is significant (0.02 level).

The mean PSRT values obtained from control, diabetic, POAG and cataract groups per age class are shown in Table 2 and the comparison within each age class are shown in Table 3. From these comparisons statistically significant differences are evident between the diabetic and control groups in the younger age class (class A). However, no statistical significant differences were found in the other two age classes when, controls, diabetics and POAG groups, and controls, diabetics and cataracts groups were compared.

Table 1. Comparison between the right and left eye of controls for photostress recovery time (PSRT).

		43-54 (years)		55-64 (years)		65-74 (years)	
		OD	OE	OD	OE	OD	OE
Controls	n° subjects	26	17	23	13	15	7
	PSRT (min; max)	14; 46	15; 45	16; 49	15; 53	15; 53	18; 47
	[sec]	24.85±7.84	28.12±8.93	28.96±10.06	27.15±9.97	34.00±9.86	27.43±9.76
Statistics	PSRT (mean±SD)						
	[sec]						
	t-test	t=1.266 df=41 p=0.2126		t=0.5181 df=34 p=0.6077		t=1.461 df=20 p=0.1596	
Statistical difference		No		No		No	

Table 2. Mean photostress recovery time (PSRT) and other relevant data obtained from control, diabetic, POAG and cataract groups. Asterisk data were not considered for further analysis due to the reduce number of subjects ($n \leq 6$). VA stands for visual acuity (decimal scale) and PSD for pattern standard deviation.

Group		43-54 (years)	55-64 (years)	65-74 (years)
Control	Age (mean±SD) [years]	49.98±3.06	59.69±2.91	68.5±3.00
	n° subjects	43	36	22
	PSRT (min; max) [sec]	14; 46	15; 53	15; 53
	PSRT (mean±SD) [sec]	26.14±8.34	28.31±9.92	31.91±10.09
Diabetic	Age (mean±SD) [years]	50.11±3.45	58.29±2.48	68.80±2.43
	n° subjects	18	28	15
	PSRT (min; max) [sec]	12; 43	15; 84	15; 56
	PSRT (mean±SD) [sec]	20.22±7.51	28.57±14.87	30.40±11.41
POAG	Age (mean±SD) [years]	53.00±1.00	60.20±1.80	68.00±2.65
	n° subjects	3	15	3
	PSD (mean±SD) [db]	2.85±1.35	4.83±3.64	8.02±3.40
	PSRT (min; max) [sec]	27; 57	14; 75	23; 34
Cataract	PSRT (mean±SD) [sec]	34±20.42*	36.87±16.29	27.67±5.69*
	Age (mean±SD) [years]	No available data	59±3.10	71.29±2.76
	n° subjects		6	17
	VA (median; min; max)		(0.65; 0.3; 0.8)	(0.6; 0.2; 0.8)
	PSRT (min; max) [sec]		22; 43	22; 70
	PSRT (mean±SD) [sec]		29.67±7.06*	38.59±13.72

Table 3. Summary of methods used in present study and in other similar studies.

PSRT technique	Pathologies	Age (mean±SD) [years]	Visual Acuity	PSRT (mean±SD) [seconds]	Comparison
Ophthalmoscope held close to de eye as possible for an illumination period of 30 seconds.	Controls vs diabetes	49.98±3.06 50.11±3.45	≥1.0 ≥1.0	26.14±8.34 20.22±7.51	t-test: different (t=2.598; df=59; p=0.012)
	Controls vs diabetes vs POAG	59.69±2.91 58.29±2.48 60.20±1.80	≥1.0 ≥1.0 ≥1.0	28.31±9.92 28.57±14.87 36.87±16.29	Welsh: no differences (W=1.795; df1=2; df2=32.295; p=0.182)
	Controls vs diabetes vs cataract	68.50±3.00 68.80±2.43 71.29±2.76	≥1.0 ≥1.0 0.3-0.8	31.91±10.09 30.40±11.41 38.59±13.72	ANOVA (one-way): no differences (F=2.340; R ² =0.084; p=0.107)
	Controls vs POAG	59.69±2.91 60.20±1.80	≥1.0 ≥1.0	28.31±9.92 36.87±16.29	t-test: different (t=2.304, df=49, p=0.026)
	controls vs POAG	58.93±9.04 68.27±10.52	20/70-20/20 20/70-20/25	41.97±17.34 70.47±35.39	Not mentioned: different
	Controls vs BDR vs CSME vs ARMD	47.1±17.3 38.7±16.3 57.7±14.8 72.0±5.3	20/40-20/15 20/30-20/15 20/70-20/20 20/70-20-25	23.2±13.7 16.3±14.1 61.1±79.4 122.9 ±106.9	Mann-Whitney U test: different Post-hoc; controls vs BDR: no differences
	Egar Macular Stressometer. ⁶	DR vs glaucoma vs cataract vs AMD		8.4±3.0 8.6±2.4 10.0±4.3 11.8±7.6	ANCOVA: groups were not associated with PSRT

4. DISCUSSION

The best clinical technique established by Margrain and Thomson² was used to measure PSRT in people with POAG, cataracts or diabetes (non-insulin dependent) without visual signs of DR. Generically, the results showed that there was no difference between controls and the different types of eye diseases for PSRT. However, the diabetic group had a shorter PSRT than control group for the younger class of ages ranging from 43-54 years.

For controls, the effect of eye (right / left) in PSRT was not significant but age, in agreement with previous studies^{2, 16, 19}, had the effect of delaying the PSRT and appears to occur due to a gradual deterioration of macular function with increasing age.¹⁹

People with diabetes, in class A (control and diabetic groups), had faster PSRT than controls. However, diabetic group had similar PSRT to that of other groups for classes B (control, diabetic and POAG groups) and C (control, diabetic and cataract groups). It seems reasonable to assert that diseases such as diabetes may somehow change PSRT for example, by affecting the vascularity of retina or retina neuro-degeneration.^{8, 9, 20} Authors are not able to explain why this was manifested only in class A. The findings for classes B and C agreed with some previous studies where diabetes was studied together with other pathologies. For example, Wu and colleagues used an indirect ophthalmoscope for macular illumination and found a faster PSRT for the early background DR but when compared with controls the difference was not statistical significance (Table 3).⁷ Similar results were obtained by Schmitt and colleagues for moderate to mild DR when used Eger Macular Stressometer (Table 3).⁶ Other studies obtained a delay in PSRT for insulin-dependent diabetic patients.^{10, 11} The different PSRT techniques, different samples (type of Diabetes, DR severity, ages and visual acuity) and different ways of analyzing data may justify the differences among previous studies. Some of these differences are outlined in Table 3.

People with glaucoma, in class B, had similar PSRT to that of other groups. This finding agreed with some previous studies as well as conflicted with few others. For example, Schmitt and colleagues found that PSRT was not related to glaucoma.⁶ On the other hand, Sherman and Henkind, found that POAG subjects had a significant delay in PSRT when compared to control subjects.⁴ This is an apparent conflict because, if present data were analyzed the way Sherman and Henkind did (comparison between control and POAG groups) a significant delay would also be found for POAG (Table 3). Once again, methods may justify some differences between studies.

People with cataracts had similar PSRT when compared with the other groups of class C. This finding is in agreement with other previous studies⁶ and supports that PSRT is independent of cataract as long as sufficient bleaching light can reach the retina.¹⁴ This is a relevant finding since it may help to exclude the effect of cataracts when other disease is present.

Since it was proposed by Bailliant in 1954, many studies showed that PSRT has a potential as a screening tool for some retinal diseases.^{4, 5, 7} Our results confirm this potential because, we obtained consistent differences for some of the analyzed groups. However, as several studies point out, the lack of standardization is a big limitation of the PSRT test.^{2, 14} This could be the main reason for some conflicting results found in the literature and, undoubtedly, a major obstacle to overcome by warranting further studies.

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