Original Article

Normative value of photostress recovery time among various age groups in southern India

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ABSTRACT

Background: To determine the normative data and reference value for photostress recovery time (PSRT) following exposure of the macula to light, in various age groups within the Indian population.

Methods: Cross-sectional observational study performed from November 2015 to July 2016 in the Bangalore district of Karnataka state in India. We examined a total of 1,282 eyes of 641 participants and included those with corrected distance visual acuity (CDVA) scoes lower than or equal to 0.4 Logarithm of the Minimum Angle of Resolution (LogMAR). We performed the photostress procedure under standard conditions using the same approach.

Results: The mean ± standard deviation (SD) of the participants' age was 32.04 ± 15.80, with an age range of 8 to 70 years. The PSRT in participants below 16 years and above 45 years of age were significantly different compared to the 16–25-year-old age group ($P < 0.001$ for both). The PSRT values were significantly different between males and females in the reproductive age group (16 to 45 years old) ($P < 0.001$), but not in the other age groups.

Conclusions: The PSRT values were significantly different in children and older patients compared to the 16 to 25 years age group. We found that as age increased, PSRT increased significantly.

KEY WORDS

photostress recovery time, retinal diseases, macular function, normative value, optometry

INTRODUCTION

Photostress is a psychophysical method that intense light exposure could cause a temporary state of insensitivity. This is because dark adaptation takes time to restore visual sensitivity to its normal pre-exposure level [1]. The physiological basis for retinal photostress response is believed to be a fleeting condition of visual insensitivity triggered by bleaching of the visual pigments of the retina when exposed to intense light [2]. Photostress induces an afterimage in the form of a transient visual scotoma in the visual field [3]. The reappearance of sensitivity is reliant on re-synthesis of the visual pigments, which entails sufficient perfusion of the photoreceptors and the retinal pigment epithelium (RPE) [3].

Assuming that maculopathy is present, the outer retinal coats including the choroid are altered, and a protracted photostress recovery time (PSRT) can be assessed for a diagnostic clue [3]. PSRT varies with age. The acceptable recovery time of 50 to 60 seconds corresponds more to individuals over 40 years of age. Recovery time for young healthy individuals with no macular problems can be markedly less. Individuals with macular problems may

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How to cite this article: Bishwash B, Tapas Kumar D, Sanjay Kumar S, Sandip Das S, Normative value of photostress recovery time among various age groups in southern India. Med Hypothesis Discov Innov Optom. 2020 Summer; 1(1): 11-17. DOI: https://doi.org/10.51329/mehdioptometry102

Received: 02 August 2020; Accepted: 27 August 2020

exhibit recovery times lasting 1.5 to 3 minutes or longer [4].

Photostress recovery is an easy technique that can be adapted to differentiate the source of a diminished visual acuity (VA) in an eye, between a lesion in the optic nerve and a macular disease [5]. If the cause of reduced VA is the optic nerve, the bleaching of the retina will have no effect on the recovery time. Apart from being used as a diagnostic tool, it can be used to monitor the progress of diseases, such as chloroquine maculopathy, nyctalopia on vitamin A therapy, and age-related macular degeneration; and for the determination of prognosis [5]. It has also been used to monitor the progression of maculopathy in high myopia. PSRT was found to be significantly delayed in high myopia [6]. Higher PSRT values are noted in central serous retinopathy (CSR) and senile macular degeneration, along with diseases of the RPE [6], irrespective of the different sections of functional vision influenced by ocular diseases [7]. Several studies have stated that PSRT can be affected by several factors such as; aging, eye diseases, and medications [6, 8-10]. Recent studies suggest that glaucoma, an inner retinal disease, increases PSRT by a small degree [11]. Numerous systemic drugs have been mentioned to be linked with increased PSRT, including the tranquilizer Melperon [12], Oxazepam [13], alcohol [14], and Chloroquine [15].

Light adaptation is the capacity through which a visual system (or any of its constituent parts, like photoreceptors) adapts its performance to the ambient intensity of light. Regardless of the light intensity, whether increasing or decreasing, the adjustment occurs very rapidly (within seconds) [16, 17]. In cases of reduced VA associated with the ganglion cell layer of the retina or upper visual center, the expected PSRT must be within the normal range. Using PSRT, the reversal time taken for VA to return to normal after a bleached retina dazzled by bright light can be used to differentiate between abnormal and/or normal retina (especially the macula). PSRT is the interval between the removal of exposed light to the eye and the eye's ability to read letters just above their initial VA. Previous studies have shown that males have significantly higher PSRT values compared to females, and similar trends were observed in patients with diabetes compared to normal subjects [16, 18, 19]. An earlier study showed a statistically significant association of PSRT with VA, but not with age [19].

The aim of this study was to create an age-matched normative range and a reference value of PSRT among Indian residents of diverse age groups.

METHODS

We conducted a cross-sectional observational study from November 2015 to July 2016 in the Bangalore district of Karnataka State, India. The institutional ethics board of Sankara Academy of Vision reviewed the study protocol before the commencement of the study. Probability sampling was opted to restrict the bias. We obtained written informed consent through either finger impression or signature from each participant. The participants were informed about the test procedures before the consent form was signed. All individuals attending a campsite set up by a tertiary eye hospital in the city of Bangalore were examined by an experienced optometrist. We included participants with a corrected distance visual acuity (CDVA) scores lower than or equal to 0.4 logarithm minimum angle of resolution (logMAR) in both eyes. A tumbling "E" Log MAR chart (ASF68, ASF Universal brand, Delhi, India) was used for VA assessment with a digital stopwatch (102P, SASY Enterprise/1/100 sec chronograph, Gujarat, India). Patients were excluded from the study if they had severe grades of cataracts or any ocular diseases. Patients were also excluded if they had a refractive error (>± spherical equivalent of 2.0 Dioptres), glaucoma, amblyopia, and strabismus. In addition, patients were excluded if they had diabetes, hypertension, rheumatoid arthritis, or thyroid diseases.

A brief medical and ocular history of each participant was documented. We performed a cover-uncover test to exclude strabismus. The room illumination was kept constant at 200 lx and participants were kept under normal room illumination for five min. Distance VA was measured for each eye with a tumbling E log MAR chart (4 m). The fundus was examined with the help of a direct Welch Allyn ophthalmoscope (Welch Allyn Inc., Skaneateles Falls, NY, United States) powered with one Nickel-Cadmium rechargeable battery of 3.5 V (Part No.72300). The anterior segment was examined with the help of torchlight, and after 2 min (because torchlight and fundus examination might have bleached the macula), the eye with a normal pupillary reflex was exposed to a direct ophthalmoscope light held approximately 2 cm from the cornea for 10 seconds. The ophthalmoscope was checked every time before use, and illumination was set at 2,400 lx to ensure test precision. The battery of the ophthalmoscope was charged (8 h) after being used on 15 participants for 150 seconds each. The brightness of the ophthalmoscope was standardized using a lux-meter. The examination sequence of participants in different age groups was randomized. During the photostress procedure, each participant was asked to look directly into the center of the ophthalmoscope light.

For subjects wearing glasses, the examiner shifted the spectacles of the examinee downwards to shine the light,

and after the light was removed, it was returned to the previous location for VA check. To prevent reflection and transmission of light, the upper eyelid of the eye was held up by the examiner, and the ophthalmoscope light was shone with the other hand.

A digital stopwatch was used by a trained assistant to record the time of light exposure to the participants' eyes. Immediately after taking off the ophthalmoscope, the participant was requested to read the letters in the chart on the line just above the BCVA line. The elapsed time between the end of the photostress time and the duration for which the subject could precisely recognize a minimum of three or more letters above his pre-stress BCVA line was documented as the PSRT. The same procedure was performed in both eyes of all participants with a 2 min gap in between. As a standard procedure, the right eye was dazzled first. The same examiner and assistant completed the examinations. Data were descriptively analyzed first. The parametric test of the independent sampled t-test was used to equate the mean variation among groups. A two-sided $P < 0.05$ was considered statistically significant with a 95% confidence interval (CI). Data were analyzed using the IBM Statistical Package for Social Sciences (SPSS) Statistics for Windows, version 23 (IBM Corp., Armonk, N.Y., USA).

RESULTS

A total of 641 participants (1,282 eyes) were included. The participants were aged between 8 and 70 years with a mean ± standard deviation (SD) of 32.04 ± 15.80 years. Altogether, 49.77% (n = 319) were men. The overall distribution of participants in different age groups is presented in Figure 1.

We divided all the participants into six different age groups: 8–15 years, 16–25 years, 26–35 years, 36–45 years, 46–55 years, and 56–70 years. The age group of 16–25 years constituted the largest group (n = 354), whereas the age group of 56–70 years was the smallest (n = 98). We provide a detailed overview of PSRT variation in different age groups in Table 1. The minimum PSRT value for the overall population was 2.38 s (26–35 age group), and the maximum recorded was 110 s (26–35 age group). We compared the results for the age group of 16–25 years with those of other age groups. The results revealed a significant mean difference in PSRT values between the age group of 16–25 years and 8–15 years ($P < 0.001$) but not the middle-aged group of 26–45 years. Notwithstanding, there was a significant difference between older age groups of 46–55 and 56–70 years ($P < 0.001$ for all). Table 2 shows the comparative statistics of PSRT values of age groups 16 to 25 years with those of other groups.

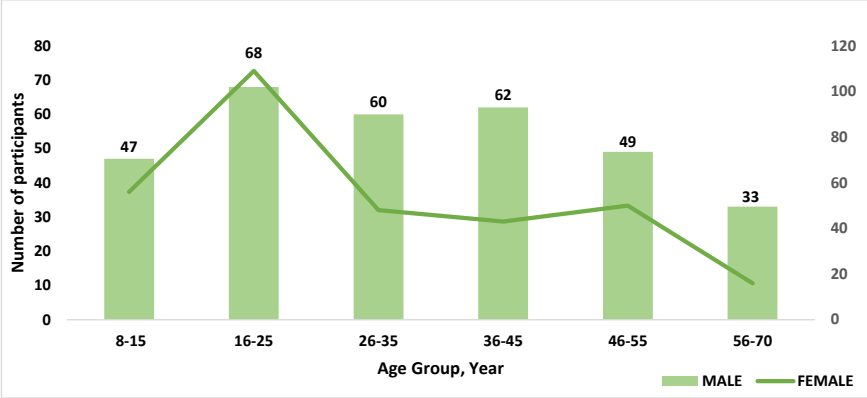

Figure 1. Demographic distribution of participants based on age group and gender.

Table 1. Descriptive statistics of PSRT values in different age groups in the study subjects

Age Group (y)	n	Mean ± SD (In seconds)
8–15	206	9.41 ± 3.33
16–25	354	33.23 ± 15.88
26–35	216	32.48 ± 14.98
36–45	210	34.81 ± 15.70
46–55	198	44.99 ± 14.95
56–70	98	47.65 ± 13.34

Abbreviations: PSRT, photostress recovery time; y, years; SD, standard deviation; n, number.

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In the overall comparison of males and females of age group 16–25 years with other age groups, a similar trend was found in the collective sample of both males and females. Tables 3 and 4 show the comparison of PSRT values of age group 16–25 years with those of other groups in males and females, respectively.

There was a considerable discrepancy in PSRT values between males and females within each age group. There was a significant difference in the case of 16–25 years ($P = 030$), 26–35 years ($P = 0.001$), and 36–45 years ($P = 0.008$), but not in other age groups. Table 5 shows the comparison of PSRT values between males and females within the same age group.

Table 2. Comparison of the PSRT values of 16–25-year age group with that of other age groups

Age Group (y)	n	Mean ± SD (In seconds)	*P*-value
8–15	206	9.41 ± 3.33	**< 0.001**
26–35	216	32.48 ± 14.98	0.568
36–45	210	34.81 ± 15.70	0.256
46–55	198	44.99 ± 14.95	**< 0.001**
56–70	98	47.65 ± 13.34	**< 0.001**

Abbreviations: PSRT, photostress recovery time; y, years; SD, standard deviation; n, number; *P* < 0.05 is shown in bold.

Table 3. Comparison of PSRT values of 16–25-year age group with that of other age groups in males

Age Group (y)	n	Mean ± SD (In seconds)	*P*-value
8–15	94	9.82 ± 3.65	**< 0.001**
26–35	120	29.73 ± 15.79	0.530
36–45	124	32.46 ± 14.78	0.431
46–55	98	46.13 ± 13.70	**< 0.001**
56–70	66	47.82 ± 13.25	**< 0.001**

Abbreviations: PSRT, photostress recovery time; y, years; SD, standard deviation; n, number; *P* < 0.05 is shown in bold.

Table 4. Comparison of PSRT values of 16–25-year age group with that of other age groups in females

Age Group (y)	n	Mean ± SD (In seconds)	*P*-value
8–15	112	9.07 ± 3.02	**< 0.001**
26–35	96	35.90 ± 13.19	0.515
36–45	86	38.34 ± 16.42	0.076
46–55	100	46.13 ± 13.70	**< 0.001**
56–70	32	47.32 ± 13.71	**< 0.001**

Abbreviations: PSRT, photostress recovery time; y, years; SD, standard deviation; n, number; *P* < 0.05 is shown in bold.

Table 5. Comparison of PSRT time between male and females within the same age group

Age Group (y)	n	Mean ± SD (In Seconds)	*P*-value
8–15 (Male)	94	9.82 ± 3.64	0.112
8–15 (Female)	112	9.70 ± 3.01	
16–25 (Male)	136	30.95 ± 15.59	**0.030**
16–25 (Female)	218	34.69 ± 15.95	
26–35 (Male)	120	29.72 ± 15.78	**0.001**
26–35 (Female)	96	35.89 ± 13.19	
36–45 (Male)	124	32.45 ± 14.77	**0.008**
36–45 (Female)	86	38.33 ± 16.42	
46–55 (Male)	98	46.12 ± 13.70	1.000
46–55 (Female)	100	46.12 ± 13.70	
56–70 (Male)	66	47.82 ± 13.25	0.861
56–70 (Female)	32	47.32 ± 13.71	

Abbreviations: PSRT, photostress recovery time; y, years; SD, standard deviation; n, number; *P* < 0.05 is shown in bold.

DISCUSSION

This study revealed that the PSRT values were significantly different in children and older patients compared to the 16 to 25 years age group. We found that as age increased, PSRT increased significantly.

Macular diseases can be diagnosed long before their appearance by simply performing a photostress test [20-22]. It could be an easy clinical test to differentiate between retinal and post-retinal causes. However, there are no standard values for this test for different age and gender groups in the literature [11].

PSRT can be an easy, reproducible, and readily available method to determine retinal health status [11]. The PSRT baseline scores for the South Indian population in several age groups indicated the usual aging process of macular/retinal function. This study provided a pattern of PSRT values in men and women within different age groups. Children had a shorter PSRT, while the duration of PSRT increased beyond 46-years of age. With increasing age, the different organs changed morphologically and physiologically [22]. As the age of patients increased, the average PSRT tended to increase [20].

The present study found that an increase in age prolonged PSRT, up to a certain age. As PSRT among adults in the age range of 16 to 45 years was stable. The PSRT value in children was lower because their retinal cell has a sufficient number of photoreceptor cells in the normal retina and RPE is also functioning properly. With increasing age, the number of photoreceptor cells were consistently shown to be decreased. As per the previous study by Salvi SM et al. [22], there was a decrease in vision with an increase in age, and almost every measure of visual function showed diminishing performance with increasing age, including reduced VA, a decline in sensitivity of field of vision, reduced contrast sensitivity, and increased dark adaptation threshold. RPE, which is significant for the integrity of the rods and cones, shows expanded pleomorphism, reduction in the number of cells within the posterior pole, reduced melanin content, expanded lipofuscin content, and decreased cytoplasmic content with age [23]. Therefore, the adaption time increases with an increase in age.

As the vision of humans does not change when the cone cell in the fovea constitute 40% [23], there should be no pathological changes as well. Therefore, in the age group of 16–45 years, there was no change in PSRT time. Another possibility could be the degeneration of photoreceptor cells, which occurs slowly due to an increase in age, provided that the bleaching time is almost equal. This finding is in agreement with previously published reports [24]. It has been reported that in normal subjects, retinal macular microcirculation decreases with age. A 20% decline in normal microcirculation speed with age resembles the age-related reduction in the number of cells found in the human foveal ganglion cell layers, possibly because of the macular bleaching time, which increases after the age of 46 years [17, 23].

PSRT values of male and female participants in the age group of 8–15 years were not significantly different, but in the age group of 16–45 years, there was a significant difference with a longer PSRT duration in women compared to men. However, there was no difference in the 46–55 and 56–70 year age groups. Malik et al. showed that PSRT was higher (5 to 8 seconds) in females than in males aged between 20 to 50 years, while no significant difference was noticed in the older population [20].

A study performed in the Nigerian population by Omokhua et al. [25] investigated a PSRT range of

approximately 10 to 47 s in age groups of 11 to 70 years. These values represent the lower and upper boundaries for a normal functional retina/macula among Nigerians. In contrast, the present study recorded PSRT values of 2.38 to 110 s for participants of 8 to 70 years of age. There seems to be a difference in the lower and upper limits of PSRT, which could be simply because of the inclusion criteria for VA of 0.4 log MAR, as Omokhua et al. [25] included only 0.0 log MAR or better VA. Another reason for the higher PSRT in our study might be as a result of the underlying retinal pathology, which was not uncovered by clinical diagnosis, or just the normal aging process. This might be further translated into a gradual non-pathologic deterioration of the macula.

This study will set the normative guide and range of PSRT values in the southern Indian population, which is its main strength. However, our main limitation was that we used torchlight to evaluate the anterior segment instead of a slit-lamp. We tried to minimize the effect of this limitation by taking an accurate and detailed history, setting up detailed exclusion criteria as stated in the methods section, including participants with CDVA scoes lower than or equal to 0.4 logMAR in both eyes, and careful posterior segment examination using a direct ophthalmoscope. Nonetheless, these measures could not eliminate this effect totally. Thus, we may have under-looked for detailed ocular pathology. However, this study could be the starting point for more detailed investigations in this specific population. In addition, we used only yellow light, which was another limitation. Further studies using different light colors are needed. Thus, we propose that future studies in the same population with a detailed ocular examination and meticulous exclusion criteria, besides using different color lights be carried out to prove our values.

CONCLUSIONS

This study documented normative values of PSRT for different age groups and genders in the southern Indian population. However, well-designed future studies with detailed ocular examinations are necessary to confirm these values. We also concluded that the retinal and macular bleaching time for children (8–15years) was significantly faster compared to individuals in the age group of 26–45 years. PSRT time was stable, and again after the age of 46 years, the retinal bleaching time increased significantly, compared with the age group of 16–25 years. The retinal and macular bleaching times for males in the age group of 16–45 years was less than that in females, but, in other age groups, there was no significant difference.

ETHICAL DECLARATIONS

Ethical approval: The institutional ethics board of Sankara Academy of Vision reviewed the study protocol prior to the commencement. Written informed consent was obtained from either a finger impression or signature from each participant. The participants were informed about the test procedures before the consent form was signed.
Conflict of interest: None.

FUNDING

None.

ACKNOWLEDGMENT

First, we would like to thank Mr. Diwakar Rao Faculty and Head of Department, Sankara College of optometry, Bangalore, for helping us with this research. We also thank Mr. Aditya Goyal, Principal of Sankara Academy of Vision for supporting this study. We are also thankful to our statistician Prof. Chandrasekhar and Dr. S. Krishnaiah, who helped in the statistical part of this study.

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