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Contrast sensitivity and photostress recovery time in diabetics with and without diabetic retinopathy

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Diabetes mellitus (DM) is a major public health concern and a leading cause of diabetic retinopathy (DR), a condition that can lead to vision impairment and blindness. Early detection of retinal changes is essential in preventing vision loss. ***Purpose.*** *This study investigates the relationship between photo-stress recovery time (PSRT) and contrast sensitivity (CS) in diabetic patients with and without DR compared to healthy controls.* ***Material and methods.*** *A hospital-based comparative cross-sectional study was conducted at Al-Shifa Trust Eye Hospital, Rawalpindi, Pakistan. A total of 60 participants (age range: 40–75 years) were included, comprising 40 diabetic individuals (20 with DR and 20 without DR) and 20 healthy controls. Visual acuity, CS (using the Pelli — Robson chart), and PSRT (using a direct ophthalmoscope) were assessed. The correlation between DR and PSRT/CS was analyzed using the Spearman's correlation test, with a significance level set at $p < 0.05$.* ***Results.*** *The study found significantly lower CS and prolonged PSRT in diabetic individuals compared to controls ($p < 0.05$). Diabetic individuals with DR showed the most significant delay in PSRT. A weak negative correlation was observed between CS and DR, and a moderate positive correlation was found between PSRT and DR ($p < 0.05$).* ***Conclusions.*** *PSRT is significantly prolonged in diabetic patients, particularly those with DR, compared to non-diabetic controls. The results suggest that PSRT could serve as a reliable and simple clinical tool for early detection of DR, potentially aiding in the prevention of vision loss. Further studies with larger sample sizes are needed to explore mechanisms and therapeutic interventions to improve PSRT and CS in diabetic retinopathy patients.*

Keywords: diabetes; diabetic retinopathy; contrast sensitivity; photostress recovery time
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Контрастная чувствительность и время восстановления после фотостресса у больных диабетом с диабетической ретинопатией и без нее

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Сахарный диабет (СД) является серьезной проблемой общественного здравоохранения и одной из основных причин диабетической ретинопатии (ДР) — заболевания, которое может привести к ухудшению зрения и слепоте. Раннее выявление изменений сетчатки имеет решающее значение для предотвращения потери зрения. ***Цель*** *работы — изучение взаимосвязи между временем восстановления после фотостресса (ВВПФ) и контрастной чувствительностью (КЧ) у пациентов с СД и ДР и без нее в сравнении со здоровыми лицами группы контроля.* ***Материал и методы.*** *Сравнительное поперечное исследование проведено на*

базе глазной больнице Al-Shifa Trust, Равалпинди, Пакистан. Всего включено 60 участников в возрасте от 40 до 75 лет, включая 40 лиц с СД (20 с ДР и 20 без ДР) и 20 лиц группы контроля. Оценивались острота зрения, КЧ с использованием таблицы Пелли — Робсона и ВВПФ с использованием прямого офтальмоскопа. Корреляция между ДР и ВВПФ/КЧ анализировалась с использованием корреляционного теста Спирмена с уровнем значимости p < 0,05. ***Результаты.*** *У лиц с СД выявлена значительно более низкая КЧ и более продолжительное, чем в контроле, ВВПФ (p < 0,05). У лиц с СД и ДР наблюдалась наиболее значительная задержка ВВПФ. Между КЧ и ДР наблюдалась слабая отрицательная корреляция, а между ВВПФ и ДР – умеренная положительная (p < 0,05).* ***Заключение.*** *У пациентов с СД, особенно с ДР, ВВПФ значительно выше, чем в контроле без СД. ВВПФ может служить надежным и простым клиническим инструментом для раннего выявления ДР, потенциально способствующим предотвращению потери зрения. Необходимы дальнейшие исследования с более обширной выборкой для изучения механизмов и разработки терапевтических вмешательств, направленных на повышение ВВПФ и КЧ у пациентов с ДР.*

Ключевые слова: диабет; диабетическая ретинопатия; контрастная чувствительность; время восстановления после фотостресса
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Diabetes mellitus (DM) is a major public health concern associated with impaired metabolism of carbohydrates, proteins, and fats [1, 2]. By 2030, an estimated 9.2 million individuals in Pakistan are likely to have DM [3]. This metabolic disorder primarily involves insulin, a hormone essential for blood glucose regulation. In DM, glucose accumulates in the blood, leading to microvascular complications in major organs, including the retina [4]. Diabetic retinopathy (DR) is a leading cause of avoidable blindness globally, with one in ten type 2 DM patients at risk of vision-threatening retinopathy [5].

Photo-stress recovery time (PSRT) measures how long the macula takes to recover normal function after exposure to bright light. This process, disrupted by the bleaching of retinal pigments, is evaluated in seconds using a stopwatch [6]. Factors such as age, sex, and duration of light exposure influence PSRT, which is prolonged in conditions like DR, central serous chorioretinopathy, and age-related macular degeneration. Normative values for males are 30–40 sec, increasing with age and higher in females by 5–8 sec [6, 7].

Early detection of maculopathy in diabetes through simple outpatient tests is crucial to prevent vision loss. This study explores the relationship between PSRT and DR and its impact on contrast sensitivity (CS) in diabetic and non-diabetic individuals.

MATERIAL AND METHODS

This hospital-based comparative cross-sectional study was conducted in the Retina Department of Al-Shifa Trust Eye Hospital, Rawalpindi, Pakistan.

After obtaining approval from the Institutional Review Board (IRB), the study adhered to ethical guidelines outlined in the Helsinki Declaration. Verbal informed consent was obtained from the participants prior to their inclusion in the study. A comprehensive history was recorded using a pre-designed proforma, capturing details such as demographic information, ocular and medical history, DM duration, and treatment.

Eligible participants included diabetic patients with a disease duration of 5 years or more, aged 40 to 75 years, and a best-corrected visual acuity (BCVA) of at least 6/12 on Snellen chart, as well as those with cataracts classified as grade-1 or less according to the Lens Opacification Classification System (LOCS). Exclusion criteria encompassed individuals with BCVA below 6/12 on Snellen chart, raised intraocular pressure, glaucoma, maculopathy, age-related macular degeneration, diabetic macular edema, or retinal detachment.

A total of 60 individuals participated in the study. The mean age of the subjects included in the study was found to be 55.40 ± 10.36 years ranging from 40 to 75 years. Moreover both genders were included in the study in which 30% (n = 18) were males and 70% (n = 42) were females.

Out of 60 individuals who participated in the study, 66.7% (n = 40) were having DM whereas 33.3% (n = 20) were having no history of DM. Out of 40 diabetics, 20 presented with DR (50%). 40% of the diabetics were having DM for less than 5 years whereas 60% had DM for more than 10 years duration.

Healthy controls aged 40 to 75 years with a BCVA of 6/6 on Snellen chart in both eyes were recruited.

Participants underwent a series of assessments, beginning with visual acuity measurement using a Snellen chart at a distance of 6 m (Fig. 1). Refraction, slit-lamp examination, tonometry, and posterior segment evaluation with a 90-D lens were performed. CS was assessed using the Pelli — Robson chart at a 1-meter distance in a controlled lighting environment. The lowest contrast level at which the participants recognized the optotypes was recorded (Fig. 2).

For PSRT assessment, a fully charged direct ophthalmoscope set at maximum brightness was positioned 5 cm nasally from the eye being tested. The ophthalmoscope's light was projected onto the macula for 30 sec in a dimly lit room. During the procedure, fixation was ensured, and frequent blinking or dermatochalasis was managed. After light removal, participants were instructed to read the Pelli — Robson chart, and the time taken to return to baseline contrast sensitivity was recorded using a stopwatch. The process was repeated for both eyes (Fig. 3, A, B).

Statistics. The data was collected and analyzed to compare the outcomes among the study groups. The mean and standard deviation was reported for continuous variables whereas for the categorical variables, frequencies and percentages were reported. The data was not normally distributed, so to compare the mean CS and PSRT of the groups (diabetics with controls, and non-diabetics with controls) Mann — Whitney U-test was used whereas to find the correlation of DR with CS and PSRT Spearman's correlation was used with p-value ≤ 0.05 considered as significant.

RESULTS

The uncorrected visual acuity (UCVA) and BCVA among cases was less as compared to control group in both the eyes. The details are given in Table 1.

The contrast sensitivity among the cases was significantly less as compared to that of controls in both the right and the left eye (p = 0.000). On the other hand, PSRT was observed to be significantly higher among cases than in controls (p = 0.000). The details are given in Table 2.

A significant weak negative correlation was observed between CS and DR (p = 0.000), whereas a significant weak

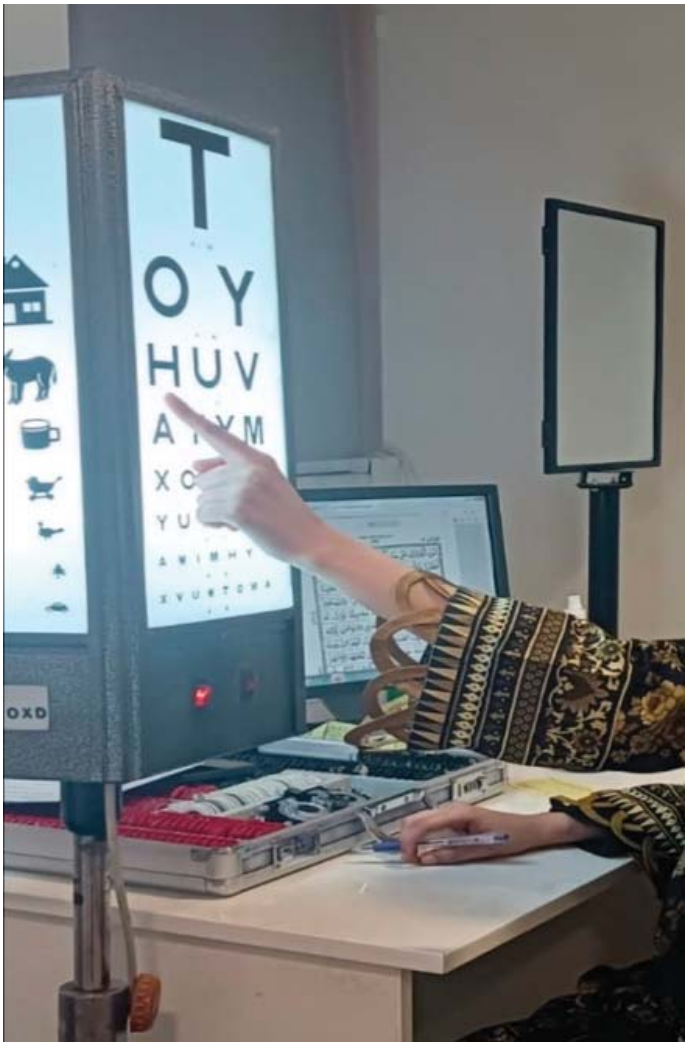

Fig. 1. Measurement of visual acuity with Snellen chart
Рис. 1. Измерение остроты зрения с помощью таблицы Снеллена

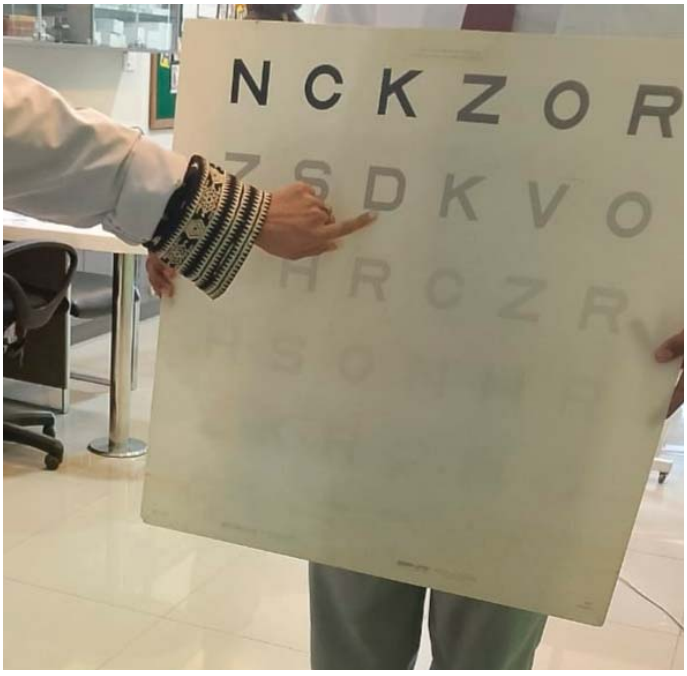

Fig. 2. Contrast sensitivity measurement using Pelli-Robson chart
Рис. 2. Измерение контрастной чувствительности с использованием таблицы Пелли — Робсона

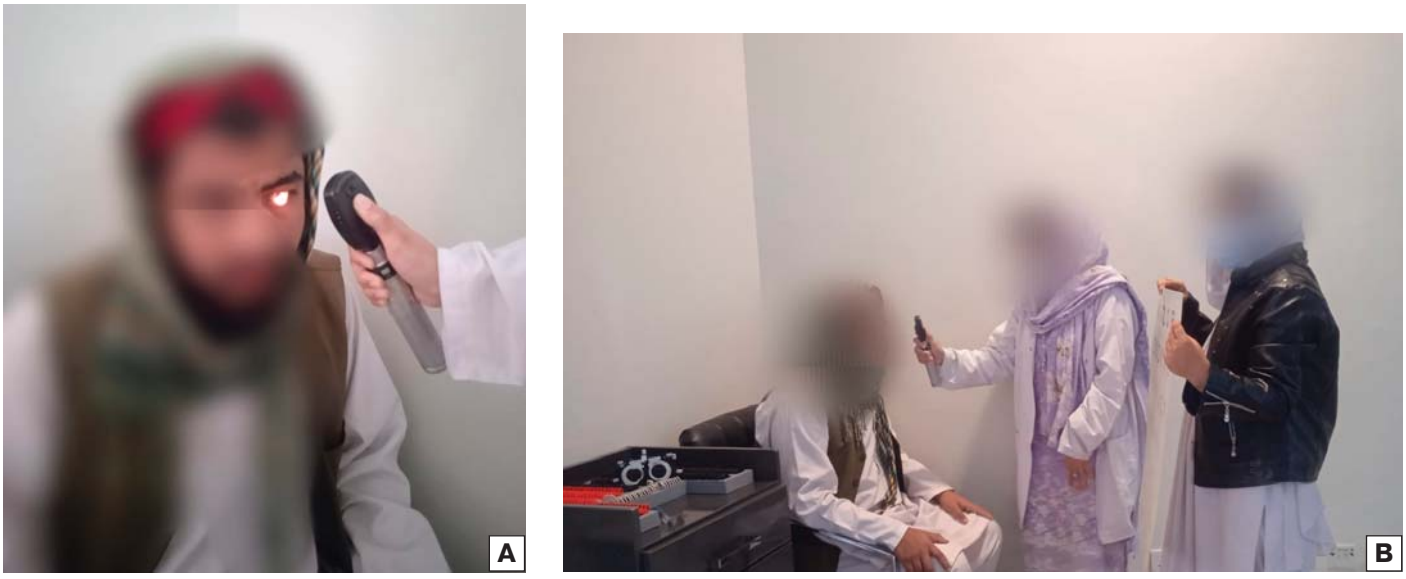

Fig. 3. Potostress recovery time measurement. Explanation in the text
Рис. 3. Определение времени восстановления после фотостресса. A — полностью заряженный прямой офтальмоскоп, установленный на максимальную яркость, располагался на расстоянии 5 см от исследуемого глаза с носовой стороны. Свет офтальмоскопа проецировался на макулу в течение 30 с в слабо освещенном помещении; B — после отключения света участникам предъявляли таблицу Пелли — Робсона, а время, необходимое для возвращения к исходному уровню контрастной чувствительности, фиксировалось с помощью секундомера

Table 1. Descriptive statistics of visual acuity (VA, Snellen equivalent) of non-diabetic and diabetic group
Таблица 1. Острота зрения (ОЗ) пациентов с сахарным диабетом (СД) и диабетической ретинопатией (ДР) и без нее

VA ОЗ	Controls Контроль				Diabetics without DR СД без ДР				Diabetics with DR СД с ДР			
	OD		OS		OD		OS		OD		OS	
	f	%	f	%	f	%	f	%	f	%	f	%
Uncorrected Некорригированная												
6/6–6/9	18	90	19	95	11	55	8	40	3	15	3	15
6/12–6/24	2	10	1	5	9	45	12	60	16	80	16	80
6/36–6/60	–	–	–	–	–	–	–	–	1	5	1	5
Best corrected Максимальная корригированная												
6/6–6/9	20	100	20	100	16	80	16	80	6	30	5	25
6/12–6/24	–	–	–	–	4	20	4	20	14	70	15	75
6/36–6/60	–	–	–	–	–	–	–	–	–	–	–	–

positive correlation was found between PSRT and DR (p = 0.000). The details are given in Table 3.

Table 2. Contrast sensitivity and photostress recovery time in diabetics and controls
Таблица 2. Контрастная чувствительность и время восстановления после фотостресса у пациентов с СД и в группе контроля

Eye Глаз	Diabetics/Control СД/Контроль	Mean ± SD	Mann — Whitney U-test	p-value
Contrast Sensitivity Контрастная чувствительность				
OD	Controls Контроль	1.64 ± 0.10		
	Diabetics with no DR СД без ДР	1.33 ± 0.15	14.000	0.000
	Diabetics with DR СД с ДР	1.22 ± 0.19	2.500	
OS	Controls Контроль	1.65 ± 0.08		
	Diabetics with no DR СД без ДР	1.33 ± 0.12	3.500	0.000
	Diabetics with DR СД с ДР	1.16 ± 0.16	0.500	
Photostress Recovery Time Время восстановления после фотостресса				
OD	Controls Контроль	36.30 ± 6.10		
	Diabetics with no DR СД без ДР	58.85 ± 10.24	389.000	0.000
	Diabetics with DR СД с ДР	77.00 ± 18.35	400.000	
OS	Controls Контроль	36.75 ± 5.50		
	Diabetics with no DR СД без ДР	61.70 ± 10.63	396.500	0.000
	Diabetics with DR СД с ДР	83.25 ± 20.86	400.000	

DISCUSSION

This study was conducted on a total of 60 individuals including 20 non-diabetics and 40 diabetics evenly divided into two groups (with and without DR). The mean age of the individuals included in the study was 55.40 ± 10.36 years (range = 40–75 years). The mean CS and PSRT of the cases was significantly different from that of control group (p=0.000). In the present study, the contrast sensitivity measurements were found to be less in diabetics with and without DR in comparison to controls (p = 0.000). The findings of the study were consistent to those reported in the previous studies. S. Safi, et al. [8] reported a uniform loss of CS at all frequencies among diabetics without DR (p < 0.05). M. Firdous, et al. [9] also found similar results and reported a reduced CS in early non-proliferative diabetic retinopathy cases in comparison to healthy controls (p = 0.001). P. Chande, et al. [10] also observed contrast sensitivity in diabetics to be less than non-diabetics (p < 0.001). Similar findings were reported by S. Pramanik, et al. [11] who observed reduced CS among diabetics with and without DR in comparison to healthy non-diabetics (p < 0.05). S. Sooryanarayana, M. Hairol [12] also reported similar results. A lower contrast sensitivity function was found in diabetics with DR as compared to those without any evident retinopathy (p = 0.004).

In the present study, the PSRT was observed to be delayed in diabetics with and without DR when compared to healthy controls. The results were found to be comparable to those reported in other studies. U. Ubani, et al. [13] reported that the PSRT was longer in diabetics with DR when compared to healthy individuals (p = 0.000). The results of our study are in accordance with the results reported in a recent study. The diabetics showed a significantly longer PSRT than in emmetropic controls (p < 0.05) [14].

The results of the present study were found to be different from those reported by A. Baptista, et al. [15], J. Loughman, et al. [16]. A. Baptista, et al. [15] reported faster recovery time as compared to controls (p = 0.012), while J. Loughman, et al. [16] observed no significant difference in PSRT values between both groups.

PSRT has been reported to be a reliable test for macular function [17]. In 2001, R. Grott, S. Chung [18] demonstrated that using low-contrast charts to measure PSRT could be a useful clinical tool for assessing macular function. The present study

Table 3. Correlation of contrast sensitivity and photostress recovery time with diabetic retinopathy
Таблица 3. Корреляции контрастной чувствительности и времени восстановления после фотостресса с наличием диабетической ретинопатии

Eye Глаз	r	p-value
Contrast Sensitivity Контрастная чувствительность		
OD	-0.534	0.00
OS	-0.654	0.00
Photostress recovery time Время восстановления после фотостресса		
OD	0.647	0.00
OS	0.657	0.00

data showed significant reduction in PSRT in those with diabetic retinopathy as compared to non-diabetics. The standard measure for PSRT through direct ophthalmoscopy in individuals aged 50 years or younger is established at 35 sec [18]. Our findings in the control group align with this norm, while our study indicates a prolonged PSRT in diabetic group. The data reveals a noteworthy delay of 31.63 sec in right eye and 36.04 sec in left eye in macular recovery time among individuals with diabetes in comparison to the control group with the same age.The present study shows positive moderate significant correlation ($p = 0.00$, $p < 0.05$) between PSRT and DR with correlation coefficient 0.647 for right eye and 0.657 for left eye. It is postulated that if a diabetic individual responds to the PSRT less than 47 sec, that person behaves similarly to a normal individual and is consequently at minimal risk of developing retinopathy. Conversely, if the response time exceeds 47 sec, the individual is considered at a high risk of developing retinopathy [6].

This study aimed to identify whether PSRT can serve as a useful clinical marker for evaluating retinal health in diabetic individuals with and without retinopathy. The outcomes of this research could have implications for the early detection and management of DR. The study's findings will contribute to a better understanding of the relationship between PSRT, contrast sensitivity, and retinal health. If a strong correlation is established, PSRT may become a valuable tool for clinicians in monitoring diabetic individuals and potentially aiding in early intervention to prevent or mitigate retinopathy-related vision loss. Additionally, the results may contribute to the development of better diagnostic and therapeutic strategies for managing diabetic eye complications.

The strength of this study is that the tests utilized are easily available in ophthalmic and optometric centers. Future studies could develop deeper into the underlying mechanisms and explore novel interventions to enhance PSRT and CS in DR patients, ultimately improving their quality of life.

This study had certain limitations. The study's sample size may be limited due to constraints such as time and resources, which could impact the generalizability of the findings. The study may not account for environmental factors such as ambient light conditions, which could impact both PSRT and CS function outcomes. The study may focus primarily on DM and retinopathy, potentially overlooking the impact of other ocular conditions that could contribute to variations in PSRT and CS function.

CONCLUSION

The current study concluded that PSRT is prolonged in patients having DR as compared to diabetics without retinopathy and non-diabetic subjects. Moreover, the findings of this study can lead to improved clinical assessments and interventions for individuals at risk of DR, ultimately contributing to better eye health and quality of life for diabetic patients.

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