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ORIGINAL RESEARCH

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Influence of prismatic effect due to decentration of optical center in ophthalmic lens

Vijay Sandeep Kumar Madrolu[1] | Shiva Ram Male[1,2] | Rishi Bhardwaj[1] | Baskar Theagarayan[3]

[1]School of Medical Sciences, University of Hyderabad, Hyderabad, India

[2]Schepens Eye Research Institute-MEEI, Department of Ophthalmology, Harvard Medical School, Boston, Massachusetts, USA

[3]Centre for Vision across the Life Span, School of Applied Sciences, University of Huddersfield, Huddersfield, UK

Correspondence
Baskar Theagarayan.
Email: b.b.pittytheagarayan@hud.ac.uk

Abstract

Background and Aims: Induced prismatic effects due to poor fitting spectacle frames is a common problem, seen in most of the spectacle wearers and this improper fitting is often due to optical center demarcation on lenses and this error causes asthenopic symptoms and diplopia. However, these errors are most common in developing countries due to lack of awareness, hence a standardized regulation is required. The current study aimed to estimate the amount of prismatic effect that is induced due to the decentration of an optical center in ophthalmic lens.

Methods: A quantitative cross-sectional study was conducted in single vision spectacle wearers ($N = 120$) with a mean age of 25 ± 5 years. The pupillometric evaluation was performed to mark the pupil center on the spectacle lens. A lensometry evaluation was done to mark the optic center of the spectacle lens. A comparison was made to note whether the optic center is aligned with pupillary center. Objective assessment was performed through Prentice's rule ($P = cF$) and subjective symptoms were assessed through a validated visual comfort questionnaire.

Results: In this sample, around 57% of the individual with single vision glasses were not looking through the optic center and experiencing induced prismatic effect of −0.7 to 0.6 prism diopter, with mean decentration of 3.5 mm. Forty percent of the individuals with misaligned optic center showed asthenopic symptoms and visual discomfort.

Conclusion: Optometrist should check quality of dispensing and visual performance before handing over the newly dispensed glasses to the patients.

KEYWORDS

decentration, interpupillary distance, optical center, prismatic effect, spectacle fitting, visual discomfort

1 | INTRODUCTION

Spectacles are the most effective means of correcting refractive problems. Compared to contact lenses, spectacles are less expensive and easier to wear, thus the vast majority of people throughout the globe use them to improve their eyesight. Every person with a refractive error may have these glasses at reasonable costs.[1,2] Preserving the optical clarity of these glasses over time is mostly dependent on proper care and maintenance.[3]

The prismatic effect that is unwittingly created into the spectacles of those wearing it is one of the reasons of the mild headache, blurred vision, eye strain, nausea, and asthenopic symptoms that contribute to visual stress that many people experience today. This is why assessing for a prismatic effect caused by decentration in the lenses is so crucial, whether the glasses are manually or automatically edged and fitted. The optician will take into account the wearer's pantoscopic tilt, splay angle, and frontal angle, as well as any other factors that may cause a prismatic effect. An optometrist will be required for the collection of eye parameters.[4,5]

A patient who has just acquired and begun wearing eyeglasses may be impacted by a prismatic effect caused by faulty optician or optometrist work.

Indian research comparing the prices of ready-made versus custom-made eyewear found that for those with low incomes, ready-made glasses were the more affordable alternative. The ready-made glasses provided comparable visual acuity to that of the more expensive custom-made glasses.[5,6] This current paper mainly focused to find out how much of an impact the delineation of the optical center in ophthalmic lenses had on the prismatic effect seen by spectacle users.

2 | METHODS

2.1 | Participants

A quantitative, cross sectional study was conducted after obtaining Ethics approval from institutional ethics committee of University of Hyderabad. A sample of ($N = 120$) with mean age 25 ± 5 (mean ± SD) years using single vision glasses for refractive correction were included in this study. This sample size comprised of a dexterously chosen batch of enrolled students studying in the University of Hyderabad campus. This sample included males and female genders, who were freely willing to participate in the study. Members with newly compensated refractive error with spectacles only were included in the study.

2.2 | Inclusion criteria

- People with refractive error and using single vision glasses only. People using spectacles less than 18 months.

2.3 | Exclusion criteria

2.3.1 | Emmetropes

- People using bifocals and progressive lenses.
- People with ocular conditions in which prism is prescribed such as strabismus.
- People with ocular diseases/pathologies.

2.4 | Experimental apparatus

Pupillometer of Akriti Company with version-5 was used to find the pupillary center and to measure the interpupillary distance of the participant. Automated lensometer of Grand Seiko with version-3.63 was used to mark the optic center and to find the power of ophthalmic lenses. DI test/scale of Akriti was used to find the amount of decentration in millimeters/centimeters. Erasable markers of Camlin with blue and green colors were used to mark the optic center of the lens. Lens cleaning solution acetone of Essilor Company was used to clean the markings over the lenses.

2.5 | Experimental procedure

People with refractive error who were using single vision glasses were selected and pupillometric evaluation was performed on them. Pupillary centers were marked and noted down along with interpupillary distance. Later with the help of an automated lensometer optical center was marked along with measuring the power of ophthalmic lenses [spectacles of subject]. Then the distance between pupillary center and optical center was measured. Next the amount of decentration with the help of a DI test was measured. By using the Prentice's rule, we have calculated the amount of prismatic effect that is induced in a spectacle due to decentration of optic center in an ophthalmic lens and the complete examination procedure was completed within 10 min.

A questionnaire on visual comfort due to induced prismatic effect was provided to individual participants and tolerance levels were assessed subjectively. This questionnaire was validated in a previous study.[7]

2.6 | Data collection and statistical analysis

The collected data was entered into a Microsoft Excel 2007 sheet and analysis of the data was performed through SPSS software version-19. Normality of the data was assessed with Shapiro–Wilk test and descriptive statistics were represented with percentage and mean distributions. Inferential statistics were measured with one way

ANOVA and one sample *t*-test to assess the association between the variables.

3 | RESULTS

The demographic data of the participants represented in percentage distribution and the interpretation can be seen at "Table 1".

The optical parameters pupillometric readings, spherical equivalent, horizontal and vertical prism of right and left eye were reported ad descriptive statistics as represented in "Table 2".

Prismatic effect in ophthalmic lenses was observed, that has been induced unknowingly due to decentration of optical center of lens. Around 57% of participants were having unwanted prismatic effect in their spectacles. The mean decentration was about 3.4 mm in both eyes. The horizontal prismatic effect induced as per Prentice's rule was −0.79 prism diopter in both right and left eye. The vertical prismatic effect induced as per Prentice's rule was −0.85 prism diopter and −0.73 prism diopter in the right and left eye, respectively. Although American National Standards Institute (ANSI) parameters have been suggested on various spectacle lenses and prism adaptations, to compare with current study we also tested to see the association between the horizontal prism [$M = -0.79\Delta$, $t = 31.84$] and vertical prism [$M = -0.85\Delta$, $t = 31.84$], 95% CI: [−0.8736 to −0.7149] and showed significance ($p < 0.05$) with one sample *t*-test, as represented in "Table 3".

We found that there was a significant ($p = 0.0253$) association between interpupillary distance spherical equivalent and TLOS through one way ANOVA test as represented in "Table 4".

Visual discomfort symptoms that is, eye ache, grittiness, fatigue, headache, glare, tiredness, confusion was assessed subjectively from all the participants and found that the asthenopic symptoms was (40%) observed in these individuals who have prismatic effect induced in spectacles, as shown in bar graph "Figure 1".

TABLE 1 Percentage wise distribution of demographic data in participants.

Demographic details		*N* = 120	*N* %
Gender	Male	53	48
	Female	67	62
Age group [years]	10–20	63	51
	20–30	47	47
	30–40	10	2
Optical center alignment	Aligned	68	57
	Not aligned	52	43
Duration of spectacles [months]	1–6	60	50
	6–12	45	46
	12–18	15	4

TABLE 2 Descriptive statistics of the participants *N* = 120.

Variables	Minimum	Maximum	Mean	Standard deviation
Pupillometer (LE)	25	35	30.24	2.76
Pupillometer (RE)	26	34	30.28	2.65
TPD	51	69	60.53	3.93
TLOS (LE)	27	36	31.79	2.52
TLOS (RE)	28	35	32.40	2.10
TLOS (IPD)	54	71	63.16	3.854
Lensometer (LE)	27	35	31.70	2.28
Lensometer (RE)	28	35	32.40	2.10
TPDL	35	70	63.77	4.50
Difference between LR-PR (mm)	0	6	3.43	1.71
Difference between LL-PL (mm)	0	6	3.40	1.64
Difference between LR-TLOS-R (mm)	0	6	3.55	1.63
Difference between LR-TLOS-R (mm)	0	6	3.33	1.45
Spherical equivalent (RE) in diopters	−6.62	4	−2.304	3.03
Spherical equivalent (LE) in diopters	−6.50	4	−2.21	2.96
Horizontal ΔD (RE)	−3.67	2.00	−0.798	1.280
Horizontal ΔD (LE)	−3.52	2.32	−0.795	1.233
Vertical ΔD (RE)	−3.44	2.40	−0.85	1.38
Vertical ΔD (LE)	−3.07	1.95	−0.73	1.228

Abbreviations: LE, left eye; LL, lensometer left eye reading; LR, lensometer right eye reading; RE, right eye; TLOS, torch light over spectacle; TPD, total pupillometric distance between two eyes.

4 | DISCUSSION

The present study investigated measuring the prismatic impact caused by the decentration of an optical center in ophthalmic lenses. The ANSI published a series of standards in 1979, one of which stated that a vertical prism with an imbalance of up to −0.33 prism diopter or 1 mm decentration of the optical center was regarded acceptable. The horizontal prismatic imbalance of up to 0.67 prism diopter or 2.5 mm decentration was also deemed acceptable.[6] In the current study, we discovered that approximately (57%) of individuals had a prismatic effect induced, with a mean of −0.7 prism diopter induced and an average decentration optical center of 3.5 mm. These results were significant according to the standards provided by the ANSI, and meanwhile, questionnaire analysis revealed that approximately (40%) of these individuals had visual complaints such as headaches and asthenopia.[8]

TABLE 3 One sample *t*-test showing the relation between the horizontal and vertical prism.

Variable	Mean (prism diopter)	*t* Value	*df*	Level of significance	95% CI	
					Lower	Upper
Horizontal prism right eye	−0.798					
Horizontal prism left eye	−0.795					
Vertical prism right eye	−0.853	31.84	3	$p < 0.001$	−0.8736	−0.7149
Vertical prism left eye	−0.731					

*$p < 0.05$ considered as significance.

TABLE 4 One way ANOVA analysis showing the association between the variables.

Variables	Right eye Mean ± SD	Left eye Mean ± SD	One way ANOVA analysis		
Pupillometry	30.28 ± 2.24	30.24 ± 2.65	*df*	*F*	Level of significance
Automated lensometry	32.40 ± 2.10	31.70 ± 2.28	3	15.91	$p = 0.0253$
TLOS (IPD)	31.39 ± 2.78	31.79 ± 2.52			

Abbreviation: TLOS, torch light over spectacle.

*$p < 0.05$ considered as significance.

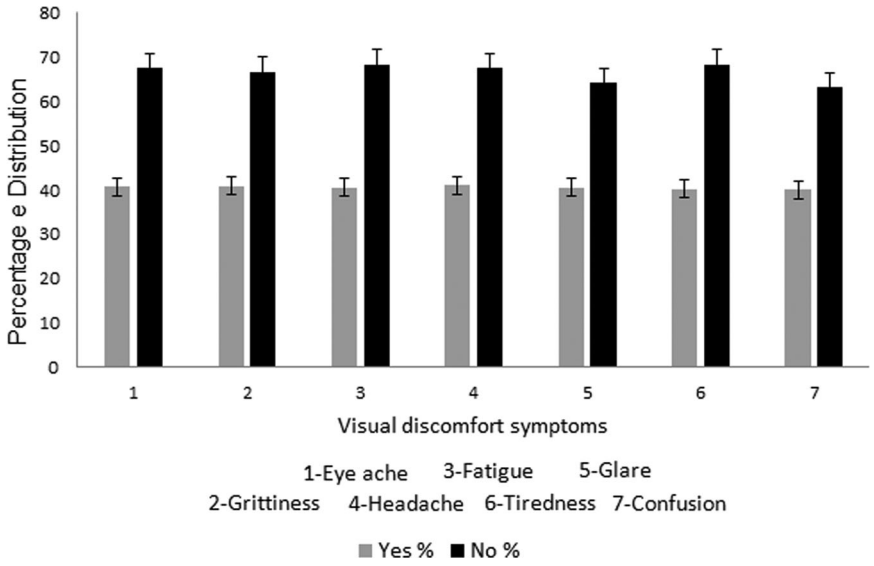

FIGURE 1 Visual discomfort symptoms.

The quantity of prism induced depends on the power of an ophthalmic lens and the displacement of optical center of the lens to the pupillary center of eye. The induced prismatic leads to reduced stereo acuity, fusional convergence, and in turn affects binocular vision status.[9–12] Similar asthenopic symptoms that is, headache, confusion, and eye ache which have an impact on binocular vision were seen more in this study.

In this study, our finding shows that (40%) spectacle users reported spectacle intolerance and asthenopic symptoms. This is higher compared to a study published in a UK population where (22%) dispensing-related intolerance was reported.[13] Inaccuracies in measuring the refractive error and/or dispensing errors and lack of knowledge about lens design have been reported as the major factors for failure of spectacle acceptance in the literature.[14,15] Our study does support the dispensing error being a major hurdle to spectacle acceptance. However, in this current study we could not find the education details of the dispensers, but we predict that based on the spectacle fitting, dispensing quality, and errors noted in optical center demarcation majority of the spectacle makers lack professional knowledge and dispensing skills for troubleshoot problems of spectacles.

Previous studies have reported significant correlation between spherical equivalent and induced prismatic affect.[16] Also, visual

discomfort was present for prism diopters greater than 1.[17] The spherical equivalent range in the present study was from −4.00 to −5.00 DS, and induced decentration was 0.7 prism diopter with a refractive power ±3.00 diopter which indicates higher intolerance and asthenopic symptoms.

The interpupillary distance in adult Caucasian individuals discovered that the best standard optical centration distance for ready-made glasses for Caucasian persons was 61 mm. This value is suitable for optical centration. In a typical person who does not have facial asymmetry, the optimal difference between the far and close interpupillary distances is 3 mm.[18]

In current study, the interpupillary distance was 60.53 mm with ±2.65SD shows that in Indian subjects also these readings were almost similar and supportive with Caucasian findings.

In this study, we primarily focused on whether there was any prismatic effect present in individuals with spectacles. We do not know whether prismatic effect occurred either due to improper fitting/edging of lenses or the primary eye care practitioner has not taken all the parameters like interpupillary distance along with accurate subjective acceptance, but we found that majority of the individuals are not looking through the optic center of an ophthalmic lens. Here we have measured only for individuals using single-vision glasses and we observed that the prismatic effect is the major cause of intolerance leading to visual discomfort in individuals with single-vision lenses and previous studies shown that the prolong use of decentered spectacle lens can lead to strabismus.[19–21]

Optometrists must raise awareness in patients since they are the ones who prescribe glasses and ensure that a set of criteria is appropriately monitored during the dispensing. Also, dispensing optician must take all the necessary steps while edging and fitting of lens to avoid unnecessary prismatic effect.

5 | CONCLUSION

This study emphasized that around 57% individuals were having prismatic effect induced in their spectacles unknowingly. Even though spectacles are prescribed by optometrist/ophthalmologist to a patient, every optometrist should check quality of dispensing and visual performance before handing over the newly dispensed glasses to the patients.

AUTHOR CONTRIBUTIONS

Vijay Sandeep Kumar Madrolu: Data curation; formal analysis; investigation; writing—original draft. **Shiva Ram Male**: Conceptualization; formal analysis; investigation; methodology; supervision; writing—original draft; writing—review and editing. **Rishi Bhardwaj**: Conceptualization; formal analysis; investigation; methodology; supervision; writing—original draft. **Baskar Theagarayan**: Conceptualization; investigation; supervision; visualization; writing—original draft; writing—review and editing. All authors have read and approved the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

All data sets generated and analyzed are available in the article. B. T. had full access to all the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis. All the necessary data is available in the manuscript itself.

ETHICS STATEMENT

This study protocol was assessed and approved by the institutional ethics committee at the University of Hyderabad.

TRANSPARENCY STATEMENT

The lead author Baskar Theagarayan affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

ORCID

Shiva Ram Male http://orcid.org/0000-0001-5872-4990
Baskar Theagarayan http://orcid.org/0000-0002-5788-3735

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