



Original Article

Effect of Spectacle Centration on Stereo Acuity: A Hospital-based Study at Madinah Teaching Hospital, Faisalabad, Pakistan.

Authors

Ayesha Arshad¹Mahr Safdar Ali Qasim²Muhammad Mujahid³

For Authors' Affiliation See Last Page of Article

Correspondence Author:

Mahr Safdar Ali QasimSenior Lecturer Optometry
Bahawalpur Medical and
Dental College, Bahawalpur.
safdarkemu@gmail.com

Objectives: To determine the possible effect on stereoacuity due to decentration, difference between optical centration distance (OCD) and interpupillary distances (IPD), and prismatic effects due to decentration of glasses.

Methods: A hospital based cross-sectional study conducted on the 100 students, with the age range of 18 to 26 years, of The University of Faisalabad in the Outpatient Ophthalmology Department at Madinah Teaching Hospital, Faisalabad. Horizontal decentration of glasses was measured by taking the difference between the interpupillary distance (IPD) and the optical center distance. Vertical decentration was evaluated by variance between the optical midpoint of the eyeglasses and the center of the pupils. Direction of decentration governs the direction of prism base and stereoacuity was judged by Titmus fly test.

Results: 100% of the sample size were using decentered glasses in both horizontal and vertical direction. In both eyes horizontally decentration was maximum (33%) in the range of 0 – 1.49 (mm). The range of vertical decentration was 3 – 5 (mm) and highest, 39% in right eye and 48% in the left eye of the individuals. Individuals having horizontal prismatic effect (PE) was 56% in their glasses in both eyes within the range of 0 – 0.49Δ. Vertically prismatic effect was inside range of 0 – 0.99Δ in all-out number of persons, 47% and 51% in the right eye and left eye respectively. Persons having induced base-in PE in their glasses was 76% in both eyes. 17% have base-out prism in their right eyes and 18% in their left eyes. Vertically induced prism was in the base-up direction in 87% and 90% of the individuals in their right and left eyes respectively and 8% and 7% base-down prisms in their right and left eyes respectively. By applying paired T test the difference between IPD (interpupillary distance) and OCD (optical centration distance) of individuals was quite significant with p-value 0.000. The mean difference between IPD and OCD was -3.57000. Mean IPD was less than the mean OCD. Chi – square test result shows that the horizontal prismatic effect in right eye causes decline in the stereo-acuity with p-value 0.019. Highest number of individuals (42) have reduction of stereo-acuity within the range of 20 – 100 minutes of arc having horizontal prismatic effect in the range of 0 – 1.49 in their right eyes.

Conclusion: PE is induced due to unfitting administration of glasses that shifts the position of image that formed on retina resulting in the reduction of the stereoacuity of the individuals.

Key Words: interpupillary distance, optical centration distance, prismatic effect (PE)

Introduction:

Stereopsis is the ability to perceive depth due to horizontal retinal image disparity in binocular vision.^{1,2} Decentration of ophthalmic lenses is one of the most important factor that effects the stereopsis and binocular vision. Fusion is one of the component of binocular vision which is affected due to the decentration of ophthalmic lenses and it results in the alteration of fusional convergence as a result, causes the asthenopic symptoms like headaches, ocular fatigue, diplopia and blurry vision.^{3,4}

One of the most common reasons in the spectacle non-tolerance is the decentration of the spectacles.⁵ When the center of one or both of the ophthalmic lenses does not coincides with the center of one or both of the pupils then these sort of spectacles are called decentered spectacles and they will cause the effect of unnecessary prisms in the spectacles.⁶ Prismatic effect is induced due to the decentration of the ophthalmic lenses and causes the distortion of stereopsis.³

Interpupillary distance (IPD) is a center to center distance between the pupils. This measurement is very important for the optical industry to properly dispense the spectacles as it determines the depth perception by stereoscopically separating the two images perceived by the brain to produce the three dimensional view.⁷ The spectacles should consists of optical centration distance equivalent to the interpupillary distance of a person, with correct ophthalmic prescription for ideal functioning of the spectacles.⁸

Induced prism is defined as the unnecessary prismatic effect when the center of the ophthalmic lenses does not coincides with the visual axis that passes from the center of one or both of the pupils.⁹ The spectacles should consists of optical centration distance equivalent to the interpupillary distance of a person, with correct ophthalmic prescription for ideal functioning of the spectacles.⁸ Ray of light bends towards the base of the prism when it passes through the prism, same as, the ophthalmic lenses also acts as a prism when the ray of light passes through the points other than the optical center of the ophthalmic lenses. The more the light ray passes from the points away from the optical center, the more strongly the light rays bends from their parallel position.¹⁰

Ophthalmic lenses acts as a set of varying power prisms. Each point away from the optical center bends the light ray by different amount. The prismatic effect is calculated from the prentice rule ($P = CF$). P denotes the prismatic effect in prism diopters, C is the distance of the point from the optical center, or decentration, measured in centimeters, F denotes the power of the ophthalmic lenses in diopters.¹¹

Some of the amount of induced prism can be tolerated by the persons without any ocular discomfort, but it depends on the type of the lenses if it is multifocal, bifocal or

monofocal lenses, prescription of ophthalmic lenses and type of the induced prisms if it is vertical or horizontal prism.¹² Atchison *et al.* (2001) investigated the effect of small prescription errors on spatial visual performance and spectacle lens acceptability.¹³

Comas *et al.* (2007) reported that difference of 0.25 D refraction between the two eyes resulted in the retinal images of two different sizes that effects the binocularity and caused asthenopic symptoms. Most of the patients could only tolerate 5% of the retinal image difference between the two eyes.¹⁴ According to ANSI standards a person can adapt upto 1/3 of the vertical prism or vertical decentration upto 1 mm and 2/3 prism diopters horizontal prismatic effect or horizontal decentration of 2.5 mm without any asthenopic symptoms.¹⁵ Induced vertical disparity decreases the local and global stereopsis. Local stereopsis threshold is reduced by 10 seconds of arc or less on average with 1.0Δ of induced vertical prism in front of either eye. However, global stereopsis threshold was reduced by over 100 seconds of arc by the same 1.0Δ of induced vertical prism.¹⁶ Hence opticians should be advised to take into account for the proper centralization of the spectacles so that the image of the observed objects will fall on the ideal position in the visual pathway so that the proper fusion of the image and hence stereopsis is maintained.

Materials and Methods:

A hospital-based cross sectional study was conducted from 19 April 2016 to 21st May 2016, through convenient sampling to include 100 students of The University Of Faisalabad, of age group 18 to 26 years, to assess the decentration in their spectacles and its effect on the stereoacuity, conducted at the department of Ophthalmology at Madinah Teaching Hospital, Faisalabad, Pakistan.

Inclusion criteria: Subjects using monofocal spectacles. Subjects visual acuity 6/6 bilaterally with spectacles. Age ranges from 18 to 26 years of age. Subjects orthophoric with spectacles.

Exclusion criteria: Subjects using bifocals or multifocals. Subjects being treated for any ocular pathologies. Subjects with significant phorias/tropias. Data were collected by getting signs from the subjects on an informed consent form. Only those subjects were included in the study who gave their consent.

Objective tests for the diagnosis of centration of spectacles was assessed by marking the center of the spectacles by the marker in focimeter. Interpupillary distance was measured by the IPD ruler. Measurement was taken from the center of pupillary reflex of one eye to the center of pupillary reflex of the other eye. Horizontal decentration was assessed by the difference between the interpupillary

distance (IPD) assessed by the IPD ruler and the optical centration distance (OCD) assessed by the measurement taken from center to center points on the ophthalmic lenses marked by the focimeter. Vertical decentration was assessed by the centimeter ruler. Points were marked on the spectacles where the center of the pupil was visible. Centimeter ruler was used to measure the difference between the points marked for the center of pupil on the spectacles and the points marked by the focimeter that represents the center of the optical lenses. Stereoacuity was measured by the Titmus Fly Test (TFT). Visual acuity was measured from the Snellen chart. Prismatic effect was calculated from the Prentice formula. ($P=CF$)

Results:

One hundred individuals were observed, in which horizontal decentration in right eye and left eye was highest in the range of 0 – 1.49mm in 33% of the individuals and lowest 6 – 7.5mm in 2% individuals (Table 1). Vertical decentration in right and left eye was 3 – 5mm in maximum no. of individuals 39% and 48% respectively (Table 2). Horizontal prismatic effect was 0 – 0.49 in 56% of individuals in right and left eye (Table 3). Vertical prismatic effect was 0 – 0.99 in 47% individuals in right eyes and 51% in their left eyes (Table 4). 76% of the individuals have prisms in base-in direction in the right and left eye of their spectacles and 17% and 18% have base-out prisms in their right and left eye of the spectacles respectively. 87% and 90% of the individuals have base-up prism in their right eye and left eye of their spectacles respectively and 8% and 7% have base-down prisms in their right and left eyes respectively (Table 5). Average of spherical powers of right eye and left eye was -2.5833 and -2.5788 respectively. Average of cylindrical powers of right eye and left eye was -0.9667 and -0.9464 respectively (Graph 6). Association between horizontal prismatic effect in right eye and stereoacuity was statistically significant with p-value 0.019 (Table 7). 76% of the individuals had stereo-acuity in the range of 20-100 minutes of arc, 13% had 101-200 and 11% were in the range of 301 or above (Table 8). Mean value of interpupillary distance (64) was less than the mean of optical centration distance (67) (Table 9). Correlation between interpupillary distance (IPD) and optical centration distance (OCD) was statistically significant with p-value 0.000 (Graph 1).

Table 1: Percentage distribution of horizontal decentration in right and left eye in spectacles.

Range of horizontal decentration Right Eye	Frequency	Range of horizontal decentration Left Eye	Frequency
0.00 - 1.49	33	0.00 - 1.49	33
1.50 - 2.99	30	1.50 - 2.99	30
3.00 - 4.49	22	3.00 - 4.49	22
4.50 - 5.99	13	4.50 - 5.99	13
6.00 - 7.50	2	6.00 - 7.50	2

Table 2: Percentage distribution of vertical decentration in right and left eye in spectacles.

Range of vertical decentration Right eye	Frequency	Range of vertical decentration Left eye	Frequency
0 – 2	18	0 – 2	25
3 – 5	39	3 – 5	48
6 – 8	27	6 – 8	20
9 – 11	15	9 – 11	7
12 – 14	1		

Table 3: Percentage distribution of horizontal prismatic effect in right and left eyes.

Horizontal prismatic effect Right eye	Frequency	Horizontal prismatic effect left eye	Frequency
0.0 - 0.49	56	0.0 - 0.49	56
0.5 - 0.99	21	0.5 - 0.99	22
1.0 - 1.49	13	1.0 - 1.49	13
1.5 - 1.99	5	1.5 - 1.99	6
2.0 - 2.49	3	2.0 - 2.49	3
2.5 - 3.00	2		

Table 4: Percentage distribution in of vertical prismatic effect in right and left eyes.

Vertical prismatic effect RIGHT eye.	Frequency	Vertical prismatic effect LEFT eye.	Frequency
0 - 0.99	47	0 - 0.99	51
1 - 1.99	34	1 - 1.99	35
2 - 2.99	10	2 - 2.99	9
3 - 3.99	6	3 - 3.99	5
4 - 5.00	3		

Table 5: Percentage distribution of horizontal prism base direction in right and left eye in spectacles.

Base direction	Right Eye	Left Eye
Base in	76	76
Base out	17	18
Base up	87	90
Base down	8	7

Table 6: Average spherical and cylindrical powers in right and left eye in the spectacles.

	Right Eye	Left Eye
Spherical power	-2.5833	-2.5788
Cylindrical power	-0.9667	-0.9464

Table 7: Association between horizontal prismatic effect in right eye in spectacles and stereoacuity.

Horizontal prismatic effect right eye	Stereoacuity		
	20-100	101-200	301 or above
0.0 - 0.49	42	8	6
0.5 - 0.99	17	1	3
1.0 - 1.49	11	2	0
1.5 - 1.99	4	1	0
2.0 - 2.49	2	1	0
2.5 - 3.00	0	0	2

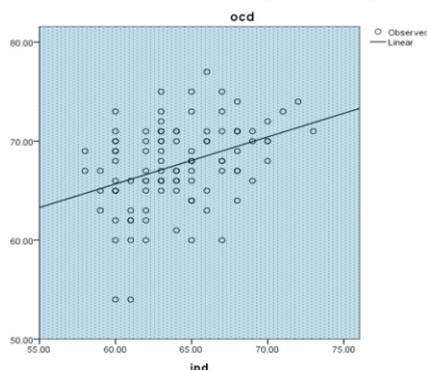
Table 8: Average of stereoacuity in different range groups

Stereoacuity Range	Frequency
20 - 100	76
101 - 200	13
> 301	11

Table 9: Comparison between IPD and OCD.

	Mean	Std. Deviation
Interpupillary distance	64	3.36044
Optical centration distance	67.6	4.2595

Graph 1: Correlation between IPD and OCD



Discussion:

100 students of The University of Faisalabad (1/6/16 - 20/7/16) were observed that were already using spectacles

to assess the presence or absence of the dispensing errors in their spectacles and its effect on stereo-acuity with Titmus Fly Test. Individuals with presence or absence of decentration in their spectacles were observed and all other dispensing errors were excluded in the study. It was observed that 100% of the individuals were using decentered spectacles in both horizontal and vertical direction.

According to VR Moodley, 45% of the individuals were wearing incorrectly dispensed spectacles. 100% of the individuals were wearing decentered spectacles among these 51% individuals were in horizontal ANSI tolerance and 3.12% were wearing vertically decentered spectacles within ANSI tolerance. 47% of the individuals had vertically induced prismatic effect in their spectacles. 50% of the individuals reported asthenopic symptoms. No correlation was reported between the induced prismatic effect and the asthenopic symptoms. 50% have base out prisms in their spectacles. 45% of the individuals were symptomatic, 12% had asthenopic symptoms, 5% were experiencing headache. Individuals wearing spectacles with base out prisms experience more symptoms as compared to others.¹⁷

Decentration was highest (33%) in the range of 0 – 1.49 (mm) horizontally in both eyes. Vertical decentration in the range of 3 – 5 (mm) was highest, 39% in right eye and 48% in the left eye of the individuals. 56% of the individuals have horizontal prismatic effect in their spectacles in right and left eye within the range of 0 – 0.49. Vertical prismatic effect was within range of 0 – 0.99 in maximum numbers of individuals, 47% and 51% in the right eye and left eye respectively. 76% have base-in prisms induced in their spectacles in both right and left eyes. 17% have base-out prism in their right eyes and 18% in their left eyes. Vertically induced prism was in the base-up direction in 87% and 90% of the individuals in their right and left eyes respectively and 8% and 7% base-down prisms in right and left eyes respectively.

According to Osuobenian and Al-Zughaibi research they also reported that 100% of the individuals were wearing decentered spectacles among which 84% had horizontal decentration and 99% were wearing vertically decentered spectacles. Most of the individuals had base-in prisms in their spectacles in horizontal direction. In vertically induced prisms, base-down prism was commonly observed in the vertically decentered spectacles.

Optical centration distance was greater than the inter-pupillary distance. Average horizontally induced prismatic effect was -0.35 in right eye and -0.33 in left eye with base-in prismatic effect. Average vertically induced prismatic effect was 1.08 in right eye and 1.09 in left eye with base-up prismatic effect in the spectacles. 5% of the individuals were reported to be symptomatic and 95% didn't complain about their spectacles.¹⁸



This is because adaptation to prisms occurs within 5 minutes after the prisms are introduced in front of the eyes.¹⁹⁻

²³Disparity effects on local and global stereopsis, induced vertical disparity reduces the local and global stereopsis. There was a significant difference in the mean stereopsis before and after inducing the vertical disparity with prism of 0.5 or 1 prism diopter ($p < 0.05$).²⁴According to Catherine, dispensing related non-tolerance of spectacles in individuals was 22%.²⁵

By applying paired sample T-test the difference between IPD and OCD of individuals was quite significant with p -value < 0.001 . The mean difference between IPD and OCD was -3.57000. Mean IPD was less than the mean OCD. Chi-square test result shows that the horizontal prismatic effect in right eye causes decline in the stereo-acuity with p -value 0.019. Highest number of individuals ($n=42$) have reduction of stereo-acuity within range of 20 – 100 minutes of arc having horizontal prismatic effect in the range of 0 - 1.49 in their right eyes.

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A Authors' Affiliation

¹Ayesha Arshad

BVS, Mphil. Optometry.
 Refractionist
 Bahawal Victoria Hospital (BVH), Bahawalpur.

²MaharSafdar Ali Qasim

Senior Lecturer Optometry.
 Bahawalpur Medical and Dental College,
 Bahawalpur

³Dr. Muhammad Mujahid

Medical Officer
 Bahawal Victoria Hospital, Bahawalpur.
 Bahawal Victoria Hospital (BVH), Bahawalpur.