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Original Article

Effect of Spectacle Centration on Stereoacuity

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Abstract

Background: To determine the percentage of decentered spectacles ,the possible relationship of decentration of spectacles on stereoacuity,the difference between interpupillary distance (IPD) and optical centration distance (OCD), the relationship between decentration of spectacles and asthenopic symptoms, magnitude of prismatic effect and the direction of base of prism in decentered spectacles.

Methods:A hospital based cross-sectional study conducted on the 100 students, with the age range of 18 to 26 years.Horizontal decentartion of spectacles was assessed by taking the difference between the interpupillary distance and the optical centration distance. Vertical decentration was assessed by difference between the optical centre of the spectacles and the centre of the pupils. Direction of decentration determines the prism base direction and stereoacuity was assessed by titmus fly test.

Results: All individuals were using decentered spectacles in both horizontal and vertical direction. 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 prism diopters. Vertical prismatic effect was within range of 0 – 0.99 prism diopters in maximum number of individuals. Majority (76%) had base-in prisms induced in their spectacles in both right and 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. Difference between IPD (inter-pupillary 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. Horizontal prismatic effect in right eye caused decline in the stereo-acuity with p-value 0.019. Highest number of individuals (42) had 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.

Conclusions: Due to improper dispensing of the spectacles, prismatic effect is induced in the spectacles that shifts the image position formed on the retina and results in the reduction of the stereoacuity of the individuals.

Key Words: Interpupillary distance, Optical centration distance, Stereoacuity, Spectacles

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 centre of one or both of the ophthalmic lenses does not coincide with the centre of one or both of the pupils then these sort of spectacles are called decentered spectacles and they will cause the affect 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 centre to centre 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 consist 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 centre of the ophthalmic lenses does not coincide with the visual axis that passes from the centre of one or both of the pupils.[9]The spectacles should consist 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 act as a prism when the ray of light passes through the points other then the optical centre 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 act as a set of varying power prisms. Each point away from the optical centre 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 centre, 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.

Patients And Methods

A hospital-based cross sectional study was conducted from April 2016 to 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. This was conducted at the department of Ophthalmology at Madinah Teaching Hospital, Faisalabad, Pakistan. Inclusion criteria was subjects using monofocal spectacles, subjects visual acuity 6/6 bilaterally with spectacles,age ranged from 18 to 26 years and orthophoric subjects with spectacles. Subjects using bifocals or multifocals, subjects being treated for any ocular pathologies and subjects with significant phorias/tropias were excluded. Objective tests for the diagnosis of centration of spectacles was assessed by marking the centre of the spectacles by the marker in focimeter. Interpupillary distance was measured by the IPD ruler. Measurement was taken from the centre of pupillary reflex of one eye to the centre 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 centre to centre points on the ophthalmic lenses marked by the focimeter. Vertical decentration was assessed by the cm ruler. Points were marked on the spectacles where the centre of the pupil was visible. Centimeter ruler was used to measure the difference between the points marked for the centre of pupil on the spectacles and the points marked by the focimeter that represents the centre of the ophthalmic lenses. Stereoacuity was measured by the Titmus Fly Test (TFT). Visual acuity was measured from the snellens chart. Prismatic effect was calculated from the Prentice formula. (P=CF)

Results

Horizontal decentration in right eye and left eye was highest in the range of 0 – 1.49mm in 33% of the individuals(Table 1). Vertical decentration in right and left eye was 3 – 5mm in maximum 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 had prisms in base-in direction in the right and left eye of their spectacles and 17% and 18% had base-out prisms in their right and left eye of the spectacles respectively. 87% and 90% of the individuals had base-up prism in their right eye and left eye of their spectacles 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 (Table 6). Association between horizontal prismatic effect in right eye and stereoacuity was statistically significant with p- value 0.019 (Table 7).

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
0-1.49	33	0-1.49	33
1.5-2.99	30	1.5-2.99	30
3-4.49	22	3-4.49	22
4.5-5.99	13	4.5-5.99	13
6-7.5	2	6-7.5	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
0-0.49	56	0-0.49	56
0.5-0.99	21	0.5-0.99	22
1-1.49	13	1-1.49	13
1.5-1.99	5	1.5-1.99	6
2-2.49	3	2.5-3	3
2.5-3	2		

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 (Figure 1)

Table 4: Percentage distribution 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	3-4	5
4-5	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 Base down	87 8	90 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	-.9667	-.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
0-0.49	42	8	6
0.5-0.99	17	1	3
1-1.49	11	2	0
1.5-1.99	4	1	0
2-2.49	2	1	0
2.5-3	0	0	2

Table 8: Average of stereoacuity in different range groups

Stero-acuity range	Frequency
20-100	76
101-200	13
301 or above	11

Table 9: Comparison between IPD and OCD

	Mean	Std. Deviation
Interpupillary distance	64.0200	3.36044
Optical centration distance	67.5900	4.25950

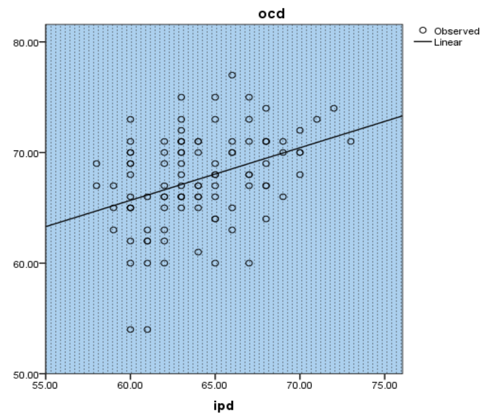

Figure 1: Correlation between IPD and OCD

Discussion

In present 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% had 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 had 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 number of individuals, 47% and 51% in the right eye and left eye respectively. 76% had base-in prisms induced in their spectacles in both right and left eyes. 17% had 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.

Osuobeni & Al-Zughaibi 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 with-in 5 minutes after the prisms are introduced in front of the eyes. [19-23]Disparity 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 ($p < 0.05$).[24]According to Catherine, dispensing related non-tolerance of spectacles in individuals was 22%.[25]By applying paired T test the difference between IPD and OCD 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 caused decline in the stereo-acuity with p-value 0.019. Highest number of individuals (42) had 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.

References

1. Wheatstone C. Contributions to the physiology of vision-part the first. On some remarkable, and hitherto unobserved, phenomena of binocular vision. Phil Trans Roy SocLond 1838; 128:371-94.
2. Bishop P O. Binocular vision. In: Moses R.A. ed. Adler's Physiology of the Eye, Clinical Application. CV Mosby 1987; 8:619-89.

3. Brooks C W. Essentials for Ophthalmic Lens Work. Chicago. Professional Press 1983.
4. Jalie M. The Principles of Ophthalmic Lenses. London. The Association of British Dispensing Opticians 1988.
5. Farrell J. Dispensing causes of non-tolerance. Optician 2005; 229:22–26.
6. Khurana A K. Theory and practice of optics and refraction. Elsevier, India 2008; 2:190-91
7. Quant J R, Woo G C. Normal values of eye position in the Chinese population of Hong Kong. Optom Vis Sci 1992; 69:152–58.
8. Brooks C W, Borish I M. System for ophthalmic dispensing. New York. Professional Press 1979; 27-65.
9. Millodot M. Dictionary of optometry and visual science. Butterworth-Heinemann. 2009; 7.
10. Safir A. Refraction and clinical optics. Hagerstown. Harper & Row 1980; 257-58.
11. Anderson A L. Accurate clinical means of measuring intervisual axis distance. Arch ophthalmol 1954; 52:349-52.
12. Du Toit R, Ramke J, Brian G. Tolerance to prism induced by readymade spectacles: setting and using standard. Am J Optom 2007; 84: 1053-59.
13. Atchison D A, Schmid K L, Edwards K P, Muller S M, Robotham J. The effect of under and over refractive correction on visual performance and spectacle lens acceptance. Ophthalmic Physiol. Opt 2001; 21:255–61.
14. Comas M, Castells X, Acosta E R, Tuni J. Impact of differences between eyes on binocular measures of vision in patients with cataracts. Eye 2007; 21:702–07.
15. Fernández-Ruiz J, Díaz R. Prism adaptation and aftereffect: specifying the properties of a procedural memory system. Learn Mem 1999; 6:47-53.
16. Fricke T R, Siderov J. Stereopsis, stereotests and their relation to vision screening and clinical practice. Clin Exp Optoin 1997; 80:165-72.
17. Moodley V R, Kadwa F, Nxumalo B, Penceliah S, Ramkalam B, Zama B. Induced prismatic effects due to poorly fitting spectacle frames. S Afr Optom 2011; 70:168-74.
18. Osuobeni E P, Al-Zughaibi, Mohammed A. Induced Prismatic Effect in Spectacle Prescriptions Sampled in Saudi Arabia. Optometry & Vision Science1993; 70:160-66.
19. Henson D B, North R. Adaptation to prism induced heterophoria. Am J Opto Physiol Opt 1980; 57:129-37.
20. Sethi B. Heterophoria : a vergence adaptive position. Ophthal Physiol Opt 1986; 6:151-16.
21. Pickwell L D and Kurtz B H. Lateral short-term prism adaptation in clinical evaluation. Ophthal Physiol Opt 1986; 6:67-73.
22. Dowley D. Heterophoria. Optom Vis Sci 1990; 67:456-60.
23. Dowley D. The Orthophorization of heterophoria. Ophthal Physiol Opt 1987; 7:169-74.
24. Moghaddam H M, Eperjesi F, Kundart J, Sabbaghi H. Induced vertical disparity effects on local and global stereopsis. Pacific University Oregon 201325.
25. Catherine E, Freeman, Bruce J W. Evans.Investigation of the causes of non-tolerance to optometric prescriptions for spectacles. Ophthal Physiol Opt 2010; 30:1–11.

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