

A COMPARATIVE STUDY OF PREVALENCE OF BINOCULAR SINGLE VISION IN HORIZONTAL STRABISMUS

Dr Varsha Singh¹, Dr Abhay Lune², Dr. Parikshit Gogate³, *Dr Sudebi Roy⁴, Dr Shivangi Bora⁵, Dr Madhav Pai⁶, Dr. Shailaja Anand⁷

1. Junior Resident, Department of Ophthalmology, Dr. D. Y. Patil Medical College and Hospital, Pune, Maharashtra, India
2. Professor, Department of Ophthalmology, Dr. D. Y. Patil Medical College and Hospital, Pune, Maharashtra, India
3. Associate Professor, Department of Ophthalmology, Dr. D. Y. Patil Medical College and Hospital, Pune, Maharashtra, India
4. Junior Resident, Department of Ophthalmology, Dr. D. Y. Patil Medical College and Hospital, Pune, Maharashtra, India
5. Junior Resident, Department of Ophthalmology, Dr. D. Y. Patil Medical College and Hospital, Pune, Maharashtra, India
6. Junior Resident, Department of Ophthalmology, Dr. D. Y. Patil Medical College and Hospital, Pune, Maharashtra, India
7. Junior Resident, Department of Ophthalmology, Dr. D. Y. Patil Medical College and Hospital, Pune, Maharashtra, India.

***Corresponding Author:**

Dr Sudebi Roy,

Junior Resident, Department of Ophthalmology, Dr. D. Y. Patil Medical College and Hospital, Pune, Maharashtra, India

ABSTRACT

Aim: The aim of this study was to evaluate and compare the prevalence of Binocular Single Vision in cases with horizontal strabismus and normal individual.

Methods: This Prospective Observational study was conducted at Dr. D.Y. Patil Medical College, Pune from September 2020 to August 2022 which included 100 patients of horizontal strabismus and 100 healthy individuals

Results: Out of 100 patients with horizontal strabismus, majority were male (52%) while in normal group, majority were female (55%). In strabismus, simultaneous macular perception was present in 76.19% of constant ET, 66.66% of alternating ET, 81.9% of constant XT and 91.6% of alternating XT compared to 100% in normal participants. In strabismus group, fusion was present in 33.33% of constant ET, 66.66% of alternating ET, 50.81% of constant XT and 91.6% of alternating XT compared to 100% in normal participants. In strabismus group, stereopsis was present in 33.33% of constant ET, 66.66% of alternating ET, 40.98% of constant XT and 66.66% of alternating XT compared to 93% in normal participants. In normal individuals, 100 % had gross stereopsis of 600 seconds of arc. In participants with strabismus, subjects with constant ET had gross stereopsis of 600,1000,1100 and 2000 seconds of arc in 19.04%, 4.76%, 9.52% and 66.66% of the participants respectively. Subjects with alternating ET had gross stereopsis of 600,1000,1100 and 2000 seconds of arc in 33.33%, 33.33%, 0.0% and 33.33% of the participants respectively. In the constant XT category, 22.95%, 8.19%, 9.83% and 59.01% of the participants had gross stereopsis of 600,1000,1100 and 2000 seconds of arc respectively. subjects with alternating XT had gross

stereopsis of 600,1000,1100 and 2000 seconds of arc in 33.33%, 16.66%, 33.33% and 16.66% of the participants respectively. In normal individuals, 100% participants had their fine stereopsis between 20-100 seconds of arc. In participants with strabismus, subjects with constant ET had fine depth stereopsis between 20-100, 101-200, 201-400 and >400 seconds of arc in 19.04%, 9.52%, 14.28% and 57.14% of the participants respectively.

Conclusion: In our study, in the strabismic group, all grades of binocular single vision was observed to be reduced. SMP was observed to be present in majority participants in all group however it was observed to be reduced in the strabismus groups in the next two grades of BSV. It was also observed that Alternating type of Strabismus had better BSV when compared to the constant type. Thus, early detection of BSV anomalies paves way for early treatment and thus, preservation of BSV and better quality of life.

Keywords: Binocular Single vision, Synoptophore, Titmus Fly Stereoacuity test

INTRODUCTION:

Binocular single vision (BSV) is the ability to use both eyes together to achieve a single fused percept, even in the presence of disparity of the image seen by each eye.¹ Human beings have an excellent stereopsis, which along with the large brain, upright posture, and mobile upper limbs has allowed the humans to dominate the world.

Binocular single vision development begins at 6 weeks and is completed by 6 months of life.² Binocular single vision consists of 3 grades:

1. Simultaneous macular perception
2. Fusion
3. Stereopsis.

There are, however, some conditions that disrupt binocular vision, such as amblyopia (lazy eye), or strabismus (misaligned eyes). Strabismus, a common ocular disorder in humans, may develop early in life. In general, strabismus is characterized by a misalignment of visual axes of both eyes which most often develops during the critical period of visual development.^{3,4}

Other characteristics of strabismus, however, varies among the subjects, for example, being horizontal or vertical, convergent or divergent and with variable angles of deviation.⁵

Binocular vision testing is done for Distant and Near vision and various tests are put into use to test each type.

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The synoptophore is a device that presents targets to each eye and uses them to diagnose anomalies of binocular single vision

It can be utilized to identify and assess suppression, detect retinal correspondence, measure the size and shape of a suppression scotoma, measure primary/secondary deviations, and detect fusional potential. Stereopsis, fusional amplitudes and stereopsis can also be measured on the synoptophore

Any adult with a history of childhood-onset strabismus can undergo a synoptophore exam prior to surgery, or even if they require surgery at all, as in the case of a cyclodeviation.⁶

However, in terms of testing stereopsis, a synoptophore can only determine the presence or absence of gross stereopsis, and can not be used for testing stereoacuity.

A vectograph that is viewed by using the polarized 3-dimensional glasses can be a tool for testing near stereopsis. The Stereo Fly test is designed for the evaluation of both gross stereopsis and fine depth perception.

The Wirt Stereo Test, is a vectograph test that involves polarising two targets at 90 degrees from one another and seeing them through polaroid filters to create the appearance of depth. The fly image, which takes up half of the test and can be so dramatic when viewed through

polaroid glasses as to lead little, impressionable children to start crying, exhibits the highest disparity (3000 seconds of arc).³

Following that are three animal images with numerous contour cues that span from 400 to 100 seconds in stereo disparity, and a set of circles with a stereo disparity between 800 and 40 seconds of arc. Although the test is quite robust, polarised glasses are required. The test's advantage is that even young children can easily respond to it; however, it has drawbacks, including the need for spectacles and the ease with which one can identify unocular cues, which might result in an unjustified overestimation of stereoacuity.

The current study was conducted at our tertiary care centre to determine the prevalence of binocular single vision in strabismus as compared to eyes with no motility disorders.

MATERIALS AND METHODS:

This was a prospective observational study conducted in the Department of Ophthalmology at Dr. D.Y. Patil Medical College, Hospital and Research Centre, Pune, Maharashtra, India, over a period of 18 months from September 2020 to August 2022. Before beginning the study, all patients provided written and informed consent. All the procedures were in accordance with the tenets of the Declaration of Helsinki. A sample of 100 patients in each group (strabismus and normal individuals) were taken.

Inclusion Criteria:

Cases of pure horizontal strabismus between the age group of 5-35 years were taken. Equal number of normal individuals were also included in the study

Exclusion Criteria:

All cases of Paralytic Strabismus, Vertical Strabismus, Vertical plus Horizontal Strabismus, Post-Operative cases of strabismus, age of patients less than 5 years and more than 35 years were excluded from the study.

The study was conducted at a Tertiary Care Medical College and Hospital in Western Maharashtra. This study was conducted between September 2020 to August 2022. This study includes 100 patients of Horizontal Strabismus and 100 normal individuals. All the cases of pure horizontal strabismus were selected between the age group 5-35years. A detailed history of all patients included in the study was taken which included age of onset, progress of symptoms, use of prescription spectacles, history of undergoing any convergence exercises, history of any occlusion therapy, history of similar complaints in the family, history of any head posture.

A complete ocular examination of the selected patients was done. Snellen's visual acuity chart was used to measure Uncorrected Visual Acuity (UCVA) at 6 meters distance and Best-Corrected Visual Acuity (BCVA) with refraction adjusted according to the subjects at the same distance was also measured. Extra ocular movements were checked both in ductions and versions. Detailed slit lamp evaluation was done to rule out any other ocular pathology. Direct ophthalmoscopy using a Welch Allen 3.5V Coaxial Ophthalmoscope and indirect ophthalmoscopy using a AppaSamy Indirect Ophthalmoscope to assess the central and peripheral retina and the presence or severity of any pre-existing posterior segment pathology which would exclude the subject from this study. Squint Examination included Hirschberg Test, Cover test, uncover test, Alternate Cover-Uncover test, Prism bar cover Test (PBCT). Tests for Binocular Single vision included grading of all three grades of BSV on synoptophore, namely, simultaneous macular perception, fusion and stereopsis. Gross and fine depth stereopsis was recorded on Titmus Fly stereoacuity test.

RESULT

This was a prospective observational study that included 100 clinically diagnosed cases of horizontal strabismus in one group and other group had 100 cases of normal individual.

According to the data recorded, the maximum number of patients in strabismus were male (n=52) 52%, and (n=48) 48% were females while the healthy group had 45%(n=45) and 55 were females (n=55).

In strabismus group, nearly half of them were 41 (41%) were belonged to the age group of 11-20 years, 38 (38%) in 21-30 years, 18% were 31-35 years and 3 % were 5-10 years of age. In normal group, 47% belonged to 21-30 years, 18% were 31-35 years, 33% were 11-20 years and 2% were 5-10 years of age. Both the groups were similar in terms age.

In strabismus group, out of 27 cases of esotropia, 21(21%) were the constant type and 6 (6%) of them were of the alternating type. There were 73 (73%) cases of exotropia out of which 61(61%) were of constant type and 12 (12%) were of alternating type.

In strabismus, simultaneous macular perception was present in 76.19% of constant ET, 66.66% of alternating ET, 81.9% of constant XT and 91.6% of alternating XT compared to 100% in normal participants. In strabismus group, fusion was present in 33.33% of constant ET, 66.66% of alternating ET, 50.81% of constant XT and 91.6% of alternating XT compared to 100% in normal participants. In strabismus group, stereopsis was present in 33.33% of constant ET, 66.66% of alternating ET, 40.98% of constant XT and 66.66% of alternating XT compared to 93% in normal participants.

In normal individuals, 100 % had gross stereopsis of 600 seconds of arc. In participants with strabismus, subjects with constant ET had gross stereopsis of 600,1000,1100 and 2000 seconds of arc in 19.04%, 4.76%, 9.52% and 66.66% of the participants respectively. Subjects with alternating ET had gross stereopsis of 600,1000,1100 and 2000 seconds of arc in 33.33%, 33.33%, 0.0% and 33.33% of the participants respectively. In the constant XT category, 22.95%, 8.19%, 9.83% and 59.01% of the participants had gross stereopsis of 600, 1000, 1100 and 2000 seconds of arc respectively. subjects with alternating XT had gross stereopsis of 600, 1000, 1100 and 2000 seconds of arc in 33.33%, 16.66%, 33.33% and 16.66% of the participants respectively.

In normal individuals, 100% participants had their fine stereopsis between 20-100 seconds of arc. In participants with strabismus, subjects with constant ET had fine depth stereopsis between 20-100, 101-200, 201-400 and >400 seconds of arc in 19.04%, 9.52%, 14.28% and 57.14% of the participants respectively. Subjects with alternating ET had fine depth stereopsis between 20-100, 101-200, 201-400 and >400 seconds of arc in 66.66%, 0.0%, 16.66% and 16.66 % of the participants respectively. In the constant XT category, 39.34%, 13.11%, 14.75 % and 32.78 % of the participants had fine depth stereopsis between 20-100, 101-200, 201-400 and >400 seconds of arc respectively. subjects with alternating XT had fine depth stereopsis between 20-100, 101-200, 201-400 and >400 seconds of arc in 75%, 8.33%, 8.33% and 8.33% of the participants respectively.

Table 1: Age distribution between two groups

Age groups (years)	Strabismus		Normal	
	Number	%	Number	%
5-10	3	3.0	2	2.0
11-20	41	41.0	33	33.0
21-30	38	38.0	47	47.0
31-35	18	18.0	18	18.0

Total	100	100.0	100	100.0
Chi square p value=0.569 (Not significant)				

Table 2: Gender distribution between two groups

Gender	Strabismus		Normal	
	Number	%	Number	%
Male	52	52.0	45	45.0
Female	48	48.0	55	55.0
Total	100	100.0	100	100.0
Chi square p value=0.322 (Not significant)				

Table 2: Grading of BSV on synoptophore -Simultaneous Macular Perception between two groups

SMP	STRABISMUS								NORMAL INDIVIDUAL		P value
	ET				XT				Number	%	
	Constant	%	Alt	%	Constant	%	Alt.	%			
Present	16	76.19	4	66.66	50	81.9	11	91.6	100	100.0	<0.001
Absent	5	23.81	2	33.33	11	18.1	1	8.4	0	0.0	
Total	21	100.0	6	100.0	61	100.0	12	100.0	100	100.0	

Table 4: Grading of BSV on synoptophore -Fusion between two groups

Fusion	STRABISMUS								NORMAL INDIVIDUAL		P value
	ET				XT				Number	%	
	Constant	%	Alt	%	Constant	%	Alt.	%			
											<0.00

Present	7	33.33	4	66.66	31	50.81	11	91.66	100	100.00	1
Absent	14	66.66	2	33.33	30	49.18	1	8.40	0	0.00	
Total	21	100.00	6	100.00	61	100.00	12	12.00	100	100.00	

Table 5: Grading of BSV on synoptophore -Stereopsis between two groups

Stereopsis	STRABISMUS								NORMAL INDIVIDUAL		P value
	ET				XT				Number	%	
	Constant	%	Alt.	%	Constant	%	Alt.	%			
Present	7	33.33	4	66.66	25	40.98	8	66.66	93	93.0	<0.001
Absent	14	66.66	2	33.33	36	59.01	4	33.33	7	7.0	
Total	21	100.00	6	100.00	61	100.00	12	100.00	100	100.00	

Table 6: Titmus fly stereoacuity test - Gross Stereopsis

Gross Stereopsis (Seconds of arc)	Strabismus								Normal		P value
	ET				XT				Number	%	
	Constant	%	Alt.	%	Constant	%	Alt.	%			
600	4	19.04	2	33.33	14	22.95	4	33.33	100	100.00	<0.001
1000	1	4.76	2	33.33	5	8.19	2	16.66	0	0.00	
1100	2	9.52	0	0.00	6	9.83	4	33.33	0	0.00	
2000	14	66.66	2	33.33	36	59.01	2	16.66	0	0.00	
Total	21	100.00	6	100.00	61	100.00	12	100.00	100	100.00	

Table 6: Titmus fly stereoacuity test - Fine Depth Stereopsis

Fine Depth Stereopsis (Seconds of arc)	Strabismus								Normal		P value
	ET				XT				Number	%	
	Constant	%	Alt.	%	Constant	%	Alt.	%			
20-100	4	19.04	4	66.66	24	39.34	9	75.0	100	100.0	<0.001
101-200	2	9.52	0	0.0	8	13.11	1	8.33	0	2.0	
201-400	3	14.28	1	16.66	9	14.75	1	8.33	0	0.0	
>400	12	57.14	1	16.66	20	32.78	1	8.33	0	0.0	
Total	21	100.0	6	100.0	61	100.0	12	100.0	100	100.0	

DISCUSSION

Orthoptic errors are a significant contributor to the general morbidity in our nation, although the majority of them are flagrantly disregarded or ignored.⁴ This general lack of concern for orthoptic errors has led to a increased burden of strabismus in our community. If the prevalence of squint is accepted to be between 2 and 3 percent in the general population of our country, which has more than 1 billion people, then we project that there will be approximately twenty million cases of strabismus and a similarly astounding number of cases of amblyopia and loss of stereopsis.⁴ Between 2 and 5% of preschoolers have strabismus, which is a significant contributor to visual and psychosocial impairment.^{5,6} Strabismus can appear in any field of vision, can be intermittent or constant, and can occur when the child tries to fix their gaze on a distant or close object.⁷ Rarely do newborns have their eyes in perfect alignment. The three most typical childhood eye disorders are refractive error, amblyopia and strabismus. In children and adults, strabismus is a substantial contributor to ocular morbidity, amblyopia, and psychosocial discomfort.⁸ Stereopsis, or binocular depth perception (retinal disparity), aids in understanding complicated visual experiences. Depending on the test performed, stereopsis develops between 3 and 5 months of age in early infancy and takes roughly 7 to 10 years to reach adult levels. When a baby is 5–6 weeks old, the fixation reflex begins to develop; by the time the child is 9 years old, continual conditioning has given it features similar to those of an unconditioned response. But before this age, the conditioning process stops and reverses itself, resulting in amblyopia. By the age of seven, strabismic amblyopia is almost always successfully treated, but as treatment is started later in life, the likelihood of success declines.⁹

In a study conducted by Sahai M. et al.⁴ in 2018 in Rajasthan, India, 266 strabismus cases were found among the 6283 OPD patients who were tested in total. As a result, Sahai M. et al. found that the prevalence of strabismus was 4.23%, and the majority of the walk-in patients who were screened (19.05%) were between the ages of 21 and 30. However, the majority of squint patients (23.3%) belonged to the 11–20 age range. In a research by Graham et al., conducted in United Kingdom in 1974, the prevalence of strabismus was determined to be 7.1% among 339 children who were screened only on the basis of abnormal cover tests.⁶ Studies conducted during this time period in various parts of India have revealed that 3–4% of Indians have strabismus.¹⁰ In a recent study at AIIMS, Delhi, in 2016, the prevalence of amblyopia and strabismus was determined to be 2.0% and 6.9%, respectively.¹¹

In the study conducted by Graham et al., conducted in United Kingdom in 1974, it was discovered that 22% of the population with strabismus had a reported onset of the condition before the age of 12 months and 43% during the second and third years of life. For all strabismus, the median age of onset was 29 months.⁶ Children aged 3 to 10 years old in recent research at a government hospital in Vishakhapatnam showed the highest prevalence of squint of the paediatric population tested.¹² More than half of them (52%) in the strabismus group and more than half (55%) in the normal group were male. With a p-value of 0.322, there was no gender difference that was statistically significant between the groups. The frequency was somewhat higher for boys than for girls in the Cardiff research conducted in United Kingdom (1974).⁵

A study was carried out by Praveen K. et al. in 2003 at Aravind Eye care Centre, Madurai, India to estimate the prevalence of ocular morbidity among children aged 15 years or younger of rural southern India. Of the 1,578 children who were examined, 296 (18.8%) had ocular morbidity. Conjunctival causes, including Bitot spots (108 children), refractive errors (63 children), strabismus (46 children), lid abnormalities (32 children), lens abnormalities, including cataracts and surgical aphakia (9 children), corneal scars (11 children), and globe anomalies were the most common causes of ocular morbidity (5 children). 49 (16.5%) of these children were 4 years old or younger, 125 (42.2%) were 5 to 10 years old, and another 122 (41.2%) were 10 to 15 years old. 160 (54.1%) of children with ocular morbidity were male.¹³

The stereoacuity was examined using the Titmus test at close range and the Mentor B-Vat test at a distance by O'neal and his colleagues after strabismus surgery was performed on 20 intermittent exotropes.¹⁴ In 75% at close range and 45% at a distance, stereoacuity improved. According to P.E. Waddingam, individuals with persistent exotropia had a higher likelihood of having stereoacuity (30.8%).¹⁵ Thus, if the eyes are surgically aligned appropriately, those with exotropia have a higher chance of achieving binocularity than people with esotropia. In a study conducted by Elamurugan, Vignesh et al., in 2019 in south India, 222 children with refractive error were evaluated for stereopsis on Titmus Fly stereoacuity chart. The median age in the study population was 13 ± 2.71 years. It was found that 65% of the children had normal stereo acuity, 20% had equivocal while 15% had subnormal stereoacuity.¹⁶

LIMITATIONS

This study was limited to Horizontal strabismus only and therefore, BSV in other types of strabismus could not be studied. The post-operative cases of strabismus were not included in this study and therefore, effect of surgery on BSV could not be assessed.

CONCLUSION

In our study, it was observed that the group not affected by strabismus had intact simultaneous macular perception and fusion, however, 7% participants did not have stereopsis for distance. Quantitative analysis revealed that 100% of normal individuals had gross stereopsis of 600 seconds of arc and 100% had fine depth stereopsis between 20-100 seconds of arc. In the strabismic group, however, all grades of binocular single vision was observed to be reduced. SMP was observed to be present in majority participants in all group however it was observed to be reduced in the strabismus groups in the next two grades of BSV. It was also observed that Alternating type of Strabismus had better BSV when compared to the constant type. Thus, early detection of BSV anomalies paves way for early treatment and thus, preservation of BSV and better quality of life.

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