Original Article

Assessment of stereo acuity levels using random dot stereo acuity chart in college students

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Abstract

Background and Aims: Watching 3D images are known to induce more ocular, systemic fatigue and discomfort, which can be referred to as '3D asthenopia', than watching two-dimensional (2D) images. This study was designed to determine the stereo acuity levels among college students and compare it with the hours of use of digital technology. **Methods:** University students in the age group of 18-25 years were screened for visual acuity for distance and near. Refraction was done to find the presence of refractive errors. Those students who had no vergence or accommodation dysfunction and orthophoria were only included in the study. Stereopsis was assessed using random dot stereo acuity chart. The stereo acuity results were grouped as either normal (20 arc seconds or better), Borderline (25 arc seconds to 40 arc seconds) and reduced stereopsis (50 arc seconds to 400 arc seconds). Students were also questioned about the hours of use of digital media. **Results:** The average age of the 246 participates was 20 ± 1.9 years with 78 (32%) were males and 168 (68%) were females. 7% of the population was found to be myopic in our study. The hours of use of digital technology ranged from 0-9 hours a day. Only 13.1% of the student's population met the normal level of stereopsis (20 arc seconds). Around 44.3% of the study population was found to have borderline stereopsis. Also 42.6% of the study population, reduced stereopsis was found. Among the reduced stereo acuity levels, we found stereoacuity levels as low as 100-200 arc seconds were found in nearly 17.6% of the study population. **Conclusion:** It is very much evident from this study that a large group of college students are not enjoying the highest level of binocular vision, which in turn can have a negative impact on their academic performance.

Keywords: Asthenopia, binocular vision, digital technology, randot stereo acuity test chart, stereo acuity

Introduction

Stereopsis is the depth perception of relative farness and nearness of objects where in there is small horizontal disparity that is present with fused retinal images. This small horizontal disparity is expressed as threshold disparity in terms of the angle subtended (seconds of arc) at the nodal point of the eye.[1,2] Measurements of threshold stereoacuity provide accurate information on the extent of binocular integration.[3,4] Stereotests provides accurate and repeatable measures of stereo acuity, in order to facilitate a basic vision function and binocularity. The assessment of binocular vision is an integral part of the orthoptic assessment, with the results having significant implications in terms of management and diagnostic decisions. In addition, stereopsis is important to many areas of life, such as motor skills, employment and education prospects.[5-7]

Reduced stereo acuity impinges on reading small prints, reading newspapers, pressing telephone numbers, performing handicraft/sewing, writing a check/letter/filling a form, and also influences employment and education prospects. Digital Technology has become an ever present influence on our lives. It has enormous benefit of instant communication and easy access to loads of information. Smart phones are the most common device (63%). According to AOA American Eye-Q Survey 2014, 42% spend

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greater than 3 hours per day with computers/devices. With the advent of 3D theaters as well as 3D television and computers, a noticeable increase in exposure to 3D images has set in. Watching 3D images are known to induce more ocular and systemic fatigue and discomfort, which can be referred to as '3D asthenopia', than watching two-dimensional (2D) images. There is an adverse influence of the extensive near vision demands imposed by smart phones. There is no safety guidelines for 3D display watching as such.[8] Previous study by SH Kim *et al.* has found the influence of the stereopsis and abnormal binocular vision on ocular and systemic discomfort while watching 3D television.[9]

There are several stereoacuity tests available like Titmus, Frisby, Lang, TNO stereotests. All of these tests fail to eliminate completely non-stereoscopic (monocular) depth cues and therefore, are unreliable in the accurate assessment of anomalous stereopsis. Monocular depth cues could arise from accommodation, perspective, shadows and motion parallax (caused either by head or test surface movement).[10] Random Dot stereo test is considered to be the superior to other tests and it has no monocular cues. It is limited by disparities within panum's zone. Random Dot stereo test is 10 times sensitive than other stereotest in Contour Discrimination.[11] For performance of various tasks the medical and non-medical students use virtual images of 3D media, online modules, e-learning with 3Dcomplex images which has high impact on the real depth perception of stereopsis. Moreover the demand for better stereopsis is greater among the University studying students. The visual system is biologically unsuited for the sustained near work demands of our culture. Hence this clinical study was undertaken to determine the stereo acuity levels among college students and compare it with their hours of use of digital technology.

Methods

A cross-sectional study was done among the University undergraduate medical students. The study period was between August-December 2017. The total number of students in the study were 246. Inclusion criteria were students between the age group of 18-25 years of both genders. History of chronic systemic illness, anyone using medications against systemic diseases, smokers, alcoholics, any subjects on psychoactive substance use and anyone known psychiatric illness were excluded from the study. Ethical approval was obtained 10, July 2017.

Stereopsis was assessed using Random Dot 2 Stereo Acuity test chart. Slide projectors were used to present random dot targets with equally matched luminance levels at crossed disparities ranging from 400 to 12.5 sec arc at a test distance of 40 cms. The random dot stimulus appeared as a large ring in either the right or left screen. The visual angle of the overall ring at 40 cm was 12.7°, with the edges subtending 3.6° and the central circle subtending 5.7°. The angular subtence of the dots in the pattern was 3 min arc. No Monocular cues were visible when the Polaroid glasses are worn. The screen without the stimulus projected random dot pattern with no disparity (stereo blank). Disparity levels of the stimuli included 400, 200, 160, 100, 63, 50, 40, 32, 25, 20, 16, 12.5 sec arc with the density of each slide matched to its stereo blank. All stereopsis angles were calibrated to within 1.50 sec arc of the targeted angles when viewed on the projector.

Distance and near cover test in the nine positions of gaze to determine the presence of heterophorias. Distance and near visual acuity were assessed and documented. Retinoscopy and subjective refraction performed to determine the refractive errors. Near point of convergence was measured using pencil push up method, both subjectively and objectively. Amplitude of accommodation was measured monocularly and binocularly using the push up method. To rule out presence of any gross vergence or accommodation anomalies, amplitude of accommodation and near point of convergence were assessed. A short questionnaire pertaining to the socioeconomic status, hours of near work and the type of digital technology/gadgets used regularly were ascertained. A color vision test using ishihara colour vision test plates were performed. Direct Ophthalmoscopy was performed to rule out any specific ocular disorder.

Data Analysis: Data was analyzed using the SPSS statistical program (IBM SPSS statistics 21). Pearson chi square test being analysed for the clinical significance to be found in the comparison of the duration of use of digital media and the stereoacuity levels. For discerning the clinical significance the stereo acuity levels were categorized into normal (20 arc seconds or better), Borderline (25 arc seconds to 40 arc seconds) and Reduced stereopsis (50 arc seconds to 400 arc seconds).

Results

The average age of the participant's was 20 ± 1.9 years. Of the 246 students, 78 were males and 168 were females. 7% of the study population was found to be myopic in our study. The hours of use of digital technology ranged from 0 to 8 hours a day. Only 13.1% of the student's population met the normal level of stereopsis (20 arc seconds). Around 44.3% of the study population was found to have borderline stereopsis. Also 42.6% (n = 105) of the study population were found to have reduced stereopsis. Of the 105 students with reduced stereo acuity levels, 17.6% were found to have stereopsis as low as 100-200 arc seconds [Figure 1].

A tabular column which illustrates the distribution of the stereo acuity levels among the students who have used digital media less than or equal to 4 hours and more than 4 hours [Table 1]. Based on the hours of near work, it was found that 120 students had spent less than 4 hours of using digital technology and the rest 126 had usually spent more than 4 hours with digital technology. 48.3% of the students who had spent less than or equal to 4 hours with digital technology, and 37.0% among those who had spent more than 4 hours with digital technology were found to have reduced stereopsis. The correlation between stereo acuity levels and hours of use of digital technology shows a *P* value of 0.05%.

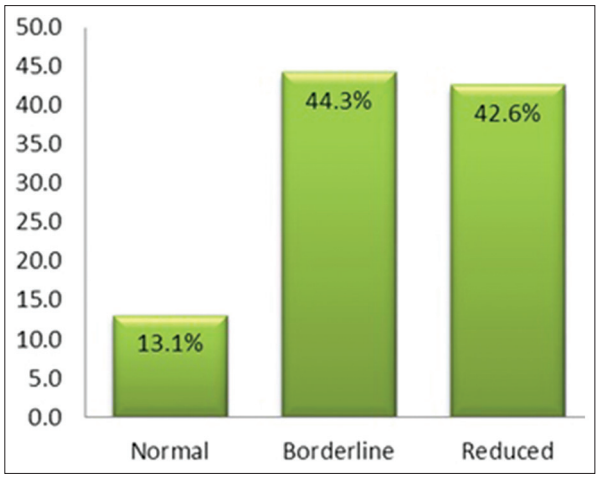

Figure 1: Stereo acuity of study population

Table 1: Stereoacuity levels comparison

Duration	Normal (%)	Borderline (%)	Reduced (%)	*P*
≤4 hrs	10 (8.30)	52 (43.30)	58 (48.30)	0.05
>4 hrs	22 (17.7)	56 (45.10)	48 (37.00)	

Discussion

Initially eyes capture the images of objects in two dimensions then the brain interprets the images through physiological mechanisms of the visual cortex and finally stereopsis occurs. The difference in the position of images of the left and right retinas are being measured in visual angles units of degrees or minutes of arc. Thus a normal binocular visual system with intact fusional mechanism is necessary to properly experience a 3D display. Clinically applicable tests of stereopsis have the potential to provide an overall assessment of refractive state, optical clarity, and contrast sensitivity and binocularity in a single test.[12,13] This is the first study in the Indian University population for the assessment of stereopsis in adults. Previously Ogle[3] reported that the mean adult near stereo-acuity of subjects with normal binocular vision is 20 seconds of arc with a standard deviation of 10 seconds of arc. In his study, 95% of the normal population had stereo-acuity thresholds of 40 seconds of arc. However in our study population, normal stereo acuity of 20 arc seconds was found in 13.1% and near to normal that is borderline of upto 40 arc seconds in 44.3%. The higher stereo acuity levels were enjoyed by people 60 years before. However, in the current scenario, this percentage is significantly reduced.

Stereopsis performance has two factors: the recognition speed factor which quantifies the complexity by the promptness of response for a disparity, and the robustness which quantifies the confidence of responses for a disparity. When the speed and robustness are delayed the stereoacuity levels are reduced. 3D technology has impact on the visual system like visual discomfort which causes three unnatural disturbances.[14] First are the excessive screen disparities too large for fusion. The second is the stereopsis distortion wherein either objects appear farther away than the fusional area or the images or parts of images for one eye is passed through the other eye that are seen as ghosting artefacts. The third is the Vergence-Accommodation mechanism.[14] These two mechanisms have to work smoothly to perceive objects clearly at a fixation distance. These performances and unnatural disturbances are the causes that definitely impacts on the stereoacuity to be reduced. Moreover, there are several others factors which influence the stereopsis such as looming, motion parallax, and the kinetic depth effect and pictorial depth cues such as occlusion, perspective, texture gradients, relative size, and height in visual field, shadow, luminance, and aerial perspective.[4,5] Because of these factors, there exists the distribution of reduced stereopsis in both the groups of students who used digital technology as illustrated in the Table 1. The amount of hours of digital technology use and stereoacuity levels had no statistical significance ($P = 0.05\%$).

Stereo acuity is the smallest amount of horizontal retinal image disparity [measured in arc seconds] giving rise to perception of relative depth or stereopsis. Monocular depth information may be sufficient for locating a target at near, however, when the target is at a distance within 2 to 3 m, more binocular depth information is required for directing daily activities, including driving and walking. Stereopsis is more important than acuity which is associated with the quality of life in all aspects of human life especially since many cataract patients have relatively good acuity at baseline. Stereopsis is used to perform a highly skilled real-world motor task essential for the occupational practice of dentistry. The clinical diagnosis of dental caries, the estimation of correct convergence in crown preparation, oral radiography interpretation and in controlling various cavity preparations. Invasive surgery is used in various specialties, requiring a novel set of motor skills and adaptation to a different viewing condition. Stereoacuity is important for all occupations such as pilot, tailoring etc. Stereopsis if reduced, then individuals are not eligible for certain professions like pilot etc. Factors affecting development of stereopsis are ocular conditions such as ametropia, aniseikonia, amblyopia, strabismus, nystagmus, aphakia, and monovision and monofixation syndrome. It is important that quality of life is dependent on the amount of stereopsis a person relatively present.[15,16]

Conclusion

This study concludes that within college groups of students, a large numbers of students do not enjoy the highest level of binocular vision. Which could therefore be a major reason for them not performing best in their academic performance and consequently having a negative impact on their careers. This results put forth the importance of routine screening of stereo acuity levels in college students. Certain limitations to be noted in our study are that we had introduced a single question of amount of hour's digital technology. A future study can be done by use a particular amount of duration of digital technology, which can be constantly maintained so that pre- and post-stereopsis can be measured.

Our study findings were limited by the small sample size. A large study population has to be chosen to bring in more light and significance of the stereopsis. A survey with questionnaires in order to clearly differentiate the symptomatic and asymptomatic students whether they possess any ocular and systemic related discomfort present and finally measure the degree of stereopsis. Further dynamic stereoacuity assessment can be made with 3D stereoscopic entertainment in the future.

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Conflict of interest

There is no conflict of interest.

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