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Original Article

A Comparative Study of Manual and Digital Methods and Stereopsis Assessment in Young Adults

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ABSTRACT

Reduced stereopsis or depth perception may be the early indicator of abnormal motor functions in people therefore, the stereopsis test is considered ideal for visual screening. It can accomplish the need for the assessment of stereopsis by using a cost-effective smartphone application. **Objective:** To compare the stereo acuity values of manual and digital stereopsis tests by using the Random Dot Stereo Acuity test with Lea Symbols (Manual) and the SAT App for Android (Digital). **Methods:** A comparative cross-sectional study was carried out in the Eye department at The University of Lahore Teaching Hospital from February 2023 to May 2023. A total of 62 subjects aged 15-35 years were included in our study, out of which 31 were emmetropes and 31 were ametropes. Screening of subjects was done which included torch light examination and basic refraction. Manually stereopsis was measured using Random Dot stereo acuity test with Lea symbols and digitally it was measured by SAT application. **Results:** The mean ± SD stereo acuity value of the manual test (N=62) was 60.5242 ± 36.47607 seconds of arc and the mean stereo acuity value of the digital test (N=62) was 70.0968 ± 28.29569 seconds of arc. P-value was 0.006 which confirmed that our results were statistically significant. **Conclusions:** Our study highlighted the comparison of digital and manual stereopsis tests. We obtained different stereo acuity values from both tests on the same individuals. Hence, the manual test gave better values of stereopsis than the digital test.

INTRODUCTION

The word stereopsis comes from Greek words meaning the power of sight and solid [1]. Stereopsis, which is the third grade of visual perception in BSV, can be measured in seconds of arc [2]. A type of vision that involves the two visual axes to meet at a point is known as binocular single vision [3]. The minimum horizontal retinal image difference (measured in arc seconds) that results in the impression of relative depth or stereopsis is called stereo acuity [4]. There are two types of stereopsis: fine and coarse. Coarse stereopsis helps one feel immersed in their surroundings and fine stereopsis tells the depth between objects [5]. In stereopsis, each eye sees slightly non-identical images that are fused to form a single, three-dimensional image [6]. Stereopsis development is disrupted by the disturbed visual system of an individual due to refractive errors in a child or an adult as they may induce vision blur due to low sensory fusion [7]. Some studies showed that the link between the activity of the neurons and the perception was well fortified in the Extrastriate Cortex [8]. Reduced stereopsis may be the early indicator of abnormal motor functions in children which is why the stereopsis test is considered ideal for visual screening [9, 10]. Random dot stereogram is a cyclopean phenomenon, which is carried out only when images of monocular eyes are combined to produce a unified percept [11]. Dr. Bela Julesz created the first RANDOM dot stereogram in 1959 as a test of stereopsis and to see in three dimensions [12]. The LEA Symbols were invented in 1976 by Dr. Lea Hyvarinen. The circle, square,

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apple, and house were all created by him to test stereo acuity identically [13]. As there are no monocular cues to depth in random-dot stereograms, they have an upper hand over other tests of stereo threshold employed in clinical or research contexts because they investigate global stereopsis [14]. In our study, to test the stereopsis of our subjects we used a Random dot stereo acuity test with Lea-symbols as a manual test. This test was constructed on the principle of random dot stereogram and formulated in a book form in which the graded circle test, the Randot test, and the shape testing for young children (Disparity ranging from 500 to 12.5 seconds of arc) were included [15]. Even though the test scoring is done at a distance of 16 inches, a minor fluctuation in the distance has little impact on the scoring [16]. The digital evaluation was done with the application named Stereo Acuity Test (SAT). It is an application designed for stereo acuity measurement in Android devices and was based on anaglyph technology. Silvia Bonfanti and Angelo Gargantin launched this application in the SE4Med (Software Engineering for Medical Devices) laboratory. In this application stereo effect was generated by random dots of two separate colors; one was making the background while the other was making a random shape in the center of it [17]. Our study aimed to compare the stereo acuity values of manual and digital stereopsis tests in individuals with refractive errors and without refractive errors. In this digital era, where smartphones are handy tools, we can accomplish the need for the assessment of stereopsis by using the application, which is cost-effective and can also become a useful tool for the assessment of stereopsis.

METHODS

Our study was a comparative cross-sectional study carried out in the eye department of Teaching Hospital of The University of Lahore from February 2023 to May 2023. A total of 62 patients were selected by using a non-probability random sampling technique. The sample size was calculated using the Cochran formula for a proportion $n_o = \frac{z^2pq}{e^2}$ The patients included were between the ages of 15-35 years. Patients with a current history of refractive surgery, ocular pathologies, and systemic disease were all excluded from our study. Patients with keratoconus were also not included in our study. Before starting our data collection procedure, we took consent from all of the patients. We commenced our study on 62 individuals with history taking to check for systemic or localized eye diseases. Then, we performed the torch light examination to see if they had any ocular pathology or manifestation. Later on, we carried out objective and subjective refraction using an Auto refractometer, Snellen chart, and a trial box on patients to check whether they needed to wear corrections during the stereopsis assessment tests. Lastly, we took the readings of stereo acuity from manual and digital stereopsis assessment tests. For the manual assessment, we asked the patients to distinguish the random dot pattern on random forms, circles, and Lea symbols on test plates of the Random dot stereo acuity test. We gave patients enough time to determine the shapes and patterns on the plates. For the digital assessment, we used the SAT application in the Samsung Galaxy A72 smartphone, which has a 1080×2400 screen resolution and density of ~393 PPI with the maximum threshold. We asked the patients to identify Lea symbols with a max resolution of stereopsis presented 30 arc secs on random dot pattern on the digital test. These tests were performed on patients at a distance of 40 cm, and the values of stereo acuity were recorded on performas. For the data analysis, we used the software, Statistical Package for the Social Sciences (SPSS version 21.0).

RESULTS

Our study was a comparative cross-sectional study. The number of participants involved in the study was 62 and 31 of them were emmetropic and the other 31 were ametropic. Division can be seen in Table 1. This study was done in The University of Lahore's teaching hospital. All the participants included in the study were between the age group of 15-31 years, with a mean age of 23.0 years as shown in Table 1. We didn't include patients older than 35 years of age as that would entail early presbyopes and might affect the results of our study. Stereo acuity was measured using the Random Dot stereo acuity test with Lea symbols (Manual) and SAT App for Android (Digital).

Table 1: Age Distribution and Stereo Acuity Comparison

Age Distribution (Emmetropes and Ametropes)			
Age of Patients (Years)	**No. of Patients**	**Emmetropia**	**Ametropia**
15-20	17	9	9
21-26	32	16	15
27-31	12	6	7
N=62		Total=31	Total=31
Stereo Acuity Comparison			
Stereopsis Tests (Sec of arc)	**Normal (20 arcsec or better)**	**Borderline (25 arc sec to 40 arcsec)**	**Reduced stereopsis (50 arc sec to 400 arcsec)**
Random Dot (Manual)	17	6	39
SAT(Digital)	0	23	39
The lowest stereo acuity in the SAT app is 38 sec of arc. It doesn't measure stereo acuity better than 38 sec of arc.			

According to the Table 2, the mean±SD stereo acuity value of the Manual test (N=62) was 60.5242 ± 36.47607 seconds of arc and the mean stereo acuity value of the Digital test (N=62) was 70.0968 ± 28.29569 seconds of arc. P-value was calculated as 0.006 from the Chi-square test and this value confirmed that our results were statistically significant.

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Both tests showed significant differences between the stereo acuity values on the same individuals as shown in Table 2. Due to the range of difference between stereo acuity values in both manual and digital tests, the SAT app was unable to measure stereo acuity better than 38 sec of arc. Hence, the Manual test gave better results in patients as it could measure stereo acuity up to 12.5 sec of arc.

Table 2: Mean stereo acuity values of digital and manual stereopsis tests with a level of significance 0.05 (P-value) and Mean age of Patients

Stereopsis Tests	N (Number of participants)	Mean ± SD (Sec of Arc)	Chi-square test Asym. Sig. (2-sided)
Random Dot (Manual)	62	60.5242±36.47607	.006
SAT(Digital)	62	70.0968±28.29569	
Age of Patients (Years)			
Minimum	**Maximum**	**Mean ± SD**	
15.00	31.00	23.0161±3.97736	

DISCUSSION

The present study states that most patients involved were between the age group of 15-35 years, with a mean age of 23.0161 years. The outcome of this study stated that there was a significant difference in stereo acuity measurement through the SAT application and the Random Dot stereoscopic test. Various studies also supported the results of our study as their outcome showed a variation in values obtained in digital and manual testing of stereopsis. The study conducted by Tittes J *et al.* researched "Assessment of stereovision with digital testing in adults and children with normal and impaired binocularity" in which compared measurements were taken using random-dot screen technology and the TNO test with anaglyph glasses. The sample size consisted of an age range of 4-59 years in which there were 34 control participants who had normal vision and 27 participants had reduced binocular single vision due to unilateral amblyopia. This study concluded that there was a difference between the level of agreement in digital and manual testing thresholds, which relates to the results of our study [18]. Similarly, Bonnie N. Posselt found similar results favoring our study by concluding digital stereopsis test which did not correlate with the manual test. Three stereo tests were performed on all 41 participants e.g. Manual TNO test and both the dynamical (dRDS-D) and static (dRDS-S) tests. The two digital versions of random dot stereogram; static and dynamic tests strongly correlated with one another but did not correlate with the manual test. The researchers found the greatest mean stereo acuity threshold with digital static random dot stereogram whereas inferior stereo acuity thresholds were found with the manual stereopsis test [19]. In our study, researchers found a mean stereo acuity statistic of 60.5242 seconds of arc for manual stereoscopic testing whereas the mean stereo acuity of SAT digital application was 70.0968 seconds of arc. Another study by Jae Wook Yang *et al.* investigated 100 children and found higher success rates of digitalized Random Dot test as compared to success rates of Randot preschool acuity (89.3%), Titmus-fly (74.2%) and Lang (86.1%) tests. Specificity was highest in the digitalized Random Dot stereo acuity test [20]. In our study, a significant difference in stereo acuity measurement was found in the Random Dot stereo acuity test and SAT App for Android.

CONCLUSIONS

Our study compared the values of stereo acuity in ametropes and emmetropes individuals by using the Random Dot stereo acuity test with Lea symbols (Manual) and the SAT App for Android (Digital). We obtained different stereo acuity values from both tests for the same individuals. Most of the patients had better stereo acuity with the manual test than with the digital test.

Authors Contribution

Conceptualization: GL, NI, MZ
Methodology: AI, AS
Formal analysis: QA, SA
Writing-review and editing: MZ, NI, AI, AS, QA, SA

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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