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A New Digital Dynamic Visual Acuity Device: Experimental Study

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ABSTRACT

Visual acuity is the spatial resolving capacity of the visual system. Dynamic Visual Acuity (DVA) defined as a very complex visual function that requires the observer to detect a moving target, to visually acquire it by eye movements, and to resolve critical details contained it, all in a relatively brief time exposure.

Aim: To create a low cost productive, portable and user friendly Digital Dynamic Visual Acuity (DDVA) Device and measure DVA.

Methodology: It is an experimental study in which there are two phases. First phase consist of creating the device and in second phase measuring the DVA in normal subjects using this device. The study was conducted between the time period of September 2017 to March 2018.First, the device was created using HTML, CSS and JAVASCRIPT language and the chart was designed and calibrated for 1 meter distance. 31 subject had undergone brief history was taken and undergone visual acuity, objective and subjective refraction. Then the Dynamic Visual Acuity was measured using this device.

Result: Total 31 subjects (age group between 17 to 28) had undergone Vision assessment and Dynamic Visual Acuity measurement using DDVA Device. There is a significant difference exists for mean static and dynamic values of decimal visual acuity ($P<0.0001$) in the studied sample. When the stratified analysis by gender was performed the similar trend was noticed ($P,0.0001$ for both the gender).

Conclusion: When compared to Static visual acuity a significant drop of Dynamic visual acuity was noticed measured using DDVA device. The device was calibrated for 45 RPM.

Key Words: Dynamic visual acuity, Static visual acuity, HTML, CSS, JAVASRIPT

INTRODUCTION

Visual acuity is the spatial resolving capacity of the visual system. It expresses the angular size of detail that can just be resolved be the observer. Static visual acuity (SVA) is the measurement of visual acuity where ability of person to recognize the smallest possible letter in visual acuity chart. Which is placed at a constant distance, here the person being tested and the chart are static [they do not move or rotate].

Dynamic Visual Acuity (DVA) defined as a very complex visual function that requires the observer to detect a moving target, to visually acquire it by eye movements, and to resolve critical details contained it, all in a relatively brief time exposure. According to committee on vision of the National Research Council in 1985 described DVA measurement as an "emergent technique". The static measures, DVA showed an impressive evidence of being more predictive performance in life.

In the world we live most of us have a dynamic environment, our ability to resolve the targets which are moving shows our performance in a variety of real-world tasks such as driving, flying or sports activities.

Several methods have been reported to measure DVA in literatures, which lack not only the standardization, but also the availability of these methods for clinical practice. Most of the methods for DVA measurement have relied on the movement(especially rotation) of a target having high contrast at a given velocity, and some studies have report the head movement (1Hz, 2Hz) will using a static target.

Some complex methods used in some of the literatures like Krishner Rotator or Keystone Rotator, and a Wayne

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Robot Rotator in which the visual acuity chart was rotated by means of either an external motor or a rotating mirror. The initial speed of rotation of the target taken was 40 RPM according to a literature.

The aim of the study is to construct/create the Digital Dynamic Visual Acuity Device(DDVA Device) and to measure dynamic visual acuity using DDVA device.

The current objectives are to measure DVA using this device, to compare DVA and SVA and also to compare between male and female subjects.

MATERIALS AND METHODS

MATERIALS:

- Lenovo B460e Laptop:
  - o core i3 1ST Gen, 2.5 Ghz,
  - o 4GB DDR3 RAM,
  - o Display:- 14.0 inches, 1366*768 pixels
- HTML file
- HTML codes
- JAVA SCRIPT
- Adobe Photoshop CC 2015
- Screen Ruler Pro

- This is a experimental study conducted on the students of Sankara College of Optometry in Bangalore India, using the device, which was designed. The study was conducted for a period of six months. The study began by taking the permission from the respective authorities of Sankara College of Optometry.
- The device was prepared and calibrated for the speed of 45RPM and chart used was calibrated for a distance of 1 meter, which was inspected by the guide and had approved for the clinical trial on 31 subjects calculated sample size. This study includes 15 males and 16 females from age 17 to 28 students of Sankara College of Optometry.
- The subjects were explained about the procedure involved in the study. A written consent form was taken from each subject prior to enrollment in to the study. The subjects were included into the study based on the inclusion and exclusion criteria of the study. All subjects who had a minimum static visual acuity of 0.0 LogMAR, and these subjects were not given any training for DVA.
- Initially history was taken about the ocular, systemic and medical history & then the visual acuity of subjects was checked for distance and near followed by objective and subjective refraction. Subjects with their best corrected visual acuity of better than or equal to 0.0 LogMAR and N6 were evaluated. Then the Dynamic Visual Acuity was measured with a constant illumination level of the room and of the screen of laptop throughout the study.

VISION ASSESSMENT

DISTANCE AND NEAR VISUAL ACUITY:

Distance visual acuity (SVA) was measured using a LogMAR chart, which was calibrated for 4 meters. The procedure was explained to the subject and the subject had closed his or her one eye and asked to read the chart from 4m distance. Further refraction was done to give best correction. Visual acuity was recorded in logarithmic units. The visual acuity was tested for both aided and unaided conditions.

Near visual acuity was measured by using N notation held at 40cm from the subject and asked them to read monocularly, near visual acuity was recorded in N notation.

OBJECTIVE REFRACTION

Subjects were made to sit comfortably, the procedure was explained, and the subject was asked to fixate the distance target i.e. largest letter size in distance acuity chart. With the retinoscope, right eye of the patient was tested with the right eye and left eye of the subject with the left eye. While moving the streak of light across the pupil, the movement of the reflex was observed. According to movement of reflex the plus or minus lenses were placed in front of over the eye using a trial frame and trial lenses. Both the meridians were similarly neutralized. The value, which was obtained after neutralization, was the gross value. The dioptric value of the arm length (+1.50 Dsph lens for a 67 cm working distance) was reduced from the gross value, which gives the net retinoscopic value.Net value was recorded in dioptric value.

SUBJECTIVE REFRACTION

Subjective refraction was carried out under fogging and by Jackson cross cylinder in case of astigmatism, duochrome was done and then prism dissociation.

First, the fogging was done by adding +2.00D to the spherical equivalent of the net value of retinoscopy then astigmatic axis was corrected by placing the JCC with its handle being the projection of the astigmatic axis. Then the JCC was flipped and the axis was changed until the subject could see no deference in the vision.

The astigmatic power was corrected by placing the JCC handle parallel to the axis. Again, the JCC was flipped and the power was changed until the subject saw no difference in the vision.

Then prism dissociation was done by placing prisms in both the eyes in oppositely facing bases. Then the subject was asked to compare the clarity of the vision in both the eyes and accordingly the power was increased and decreased until the subject saw a clear image in both the eyes.

Then Borish delayed refraction was performed, first the subject was given a near N8 target or one above the best corrected visual acuity, then plus lenses were added until the subject complains sustained blur. When the subject achieve sustained blur, then the examiner will defog the plus while giving the subject distance target (LogMAR chart 4meters) until the subject can able to read the maximum visual acuity line. And then the final prescription is given.

DYNAMIC VISUAL ACUITY

Dynamic visual acuity was carried out in a constant illumination of the room and the screen of laptop. This test was done at a distance of 1 meter and the laptop was placed at the eye level of the subject. First, the procedure was explained to the subject in the following manner:

- First, a static image of the visual acuity chart with different orientation of letters used in this device has shown to the subject and explained that it contains six lines. Of which two lines were having letter size of 6/12 target, next two lines were having letter size of 6/9 target, and last two lines having letter size of 6/6 target.
- Then explained that when examiner starts the test, subject has to read the two lines containing 6/12 target first, subject can read either of the two lines first, subject can start from any end of the lines, the line which was read has to be completed by subject then go to the next line. The subject has to read or complete the two lines of 6/12 target then proceed to the next line having 6/9 target.
- Similarly the subject has to complete the first two line of 6/12 target then next two lines of 6/9 target, then last two lines of 6/6 target in a limited time of 1 minute.

RECORDING

- The examiner will hold a booklet, which contains the letter used in the chart in the exact pattern or arrangement of letter done in the acuity chart used in the device, so the examiner follows the letters read by the subject during the test.
- Any wrong response from the subject was observed by the examiner and asked to re-read or identify the target until the subject responds it correctly.

STATISTICAL METHODS

- Average mean and standard deviation was calculated in SPSS (Statistical Package for Social Science) version 21.00.
- The descriptive statistics were calculated initially.
- The paired sample t – test was utilized to compare the mean difference of decimal visual acuity of static and dynamic vision.
- P value for confidence interval of 95% was considered significant at the $P < 0.05$level for prevalence estimate.
- Paired sample t-test value was calculated using formula:

$$N = \frac{(Z_{1-\alpha/2} - Z_{1-\beta})^2 (sd)^2}{d^2}$$

Where:

- N = Sample size.
- $Z_{1-\alpha/2} = 1.96$
- $Z_{1-\beta} = -1.28$
- sd = 0.017
- d = 0.01

- Statistical tools in Statistical package for social science (SPSS version 21.00).
- Test of Significance
- $P < 0.05$ implies that the difference statistically significant.
- $P < 0.01$ implies that the difference is highly significant.
- $P < 0.001$ implies that the difference is very highly significant.

RESULTS

A total of 31 subjects were evaluated from age group of 17 to 28 with the mean age of the patients investigated was 20.58 ± 2.36. There were 48.4% (N = 15) males and 51.6% (N=16) females. There is a significant difference exists for mean static and dynamic values of decimal visual acuity (1.016 ± 0.062 versus 0.678 ± 0.139; $P<0.0001$) in the studied sample. When the stratified analysis by gender was performed, the similar trend was noticed ($P<0.0001$ for both the gender).

According to the above results this study has shown a statistically significance between static and dynamic visual acuity.

DISCUSSION

The aim of the present study, comprising of a complementary experimental design, was to assess the construct validity and measurement of DVA using DDVA device. And the results have shown a significant difference between the static and dynamic visual acuity measured using this device.

In our study when the DVA measured using DDVA device and compared with the SVA, the results have shown a significant difference between SVA and DVA. All the subject who are having a SVA of 1.00 decimal(equivalent to 0.0 LogMAR) or greater, were found to be having lesser DVA of 0.678 ± 0.139 decimal. As the study depicts that the result is consistent with the concept of DVA described in the literatures, therefore supporting qualitative construct validity of the test.

In the study "A Novel computer software for the evaluation of dynamic visual acuity" by Quevedo L et al[1], the experiment was conducted using three different speeds (14.1, 8.58 and 1.14˚/s), the results showed a significant difference in dynamic visual acuity with increasing speeds. The DVA was good at maximum DVA score at lowest speed and decreased DVA at highest speed.Finally concluded that the DVA scores decreases as speed (velocity) increases. In many of the previous studies have also proven that the DVA decreases as the speed (velocity) of the target increases[4][5], which support the results found in our study where DVA scores have been decreased at higher speed of 45RPM (≅ 270˚/s). Thus concludes the validity of the device construction and measurement technique used in our study.

It must be noted that a direct comparison of the present findings with those reported in the above mention literature in this study is challenged by the wide range of apparatus, measurement techniques, contextual stimulus conditions, characteristics of the subjects and psychophysical methods employed by previous investigators. The need for a "gold standard", standardized test or procedure for the measurement of DVA is self-evident.

CONCLUSION

Dynamic Visual acuity is one of the important ability to resolve or recognize the moving objects or targets, which determines the performance of a person in a wide range of real-world task such as driving, flying, sports activities. In this study we have developed a device can be used to measure dynamic visual acuity in sport persons or normal persons, which of low cost and can give more accurate results. A more accurately designed chart can be used for better results.

Due to lack of standardized and validated instrument to measure DVA, we were unable to compare our results with the normative data. Instead as the subject taken in this study having no previous ocular history and having a healthy ocular condition, no physical or mental disabilities with BCVA of 0.0LogMAR, had a mean Dynamic Visual Acuity (DVA = 0.6781 SD = 0.13908) recorded using this device.

In this study, we have observed that there is a significant difference between Static and Dynamic Visual Acuity.

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conflict of interest:

All authors declare that there is no conflict of interest.

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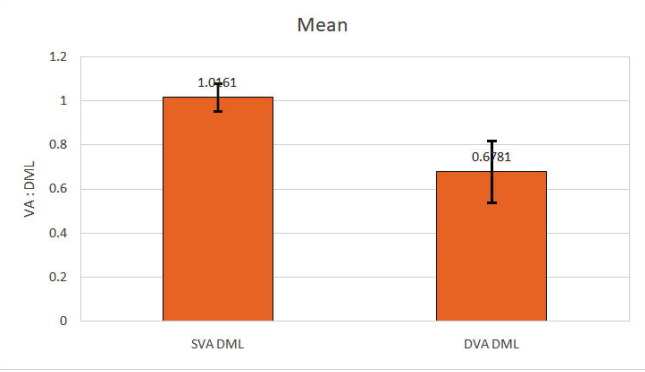

Figure 1: Mean and Standard deviation of SVA and DVA.

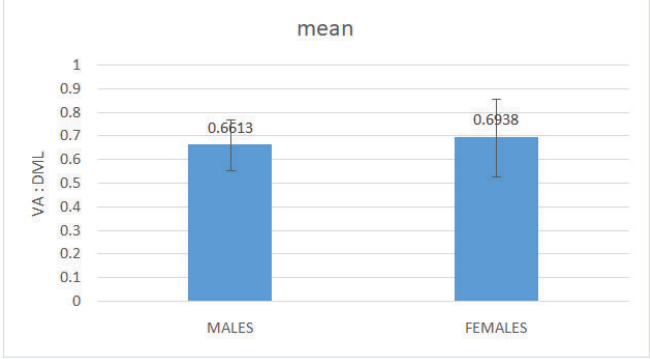

Figure 2: Mean and Standard deviation between DVA of Males and Females.

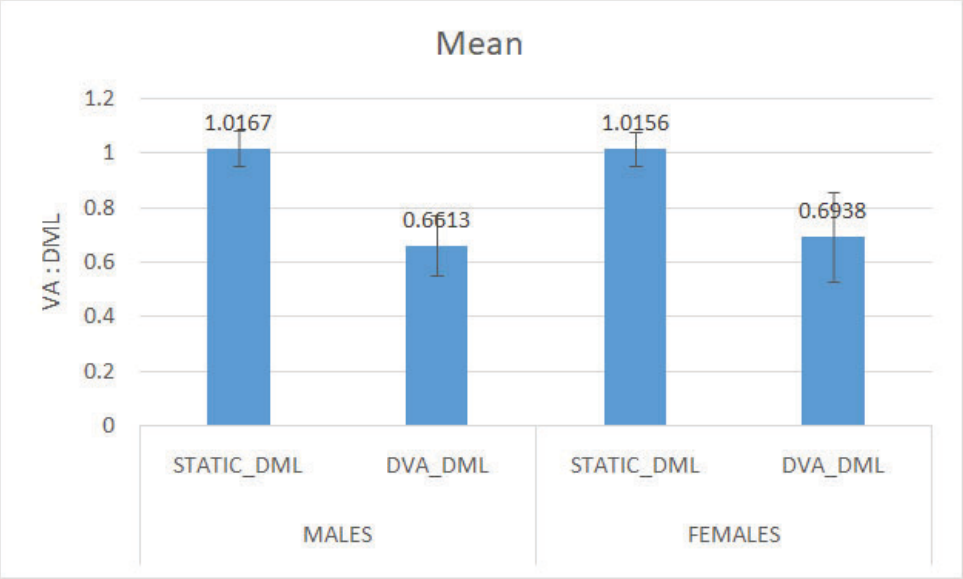

Figure 3: Mean and Standard deviation between SVA and DVA of Males and Females.