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Assessment of Dynamic Visual Acuity on VR HMD System: Focused on Exerciser and Non-Exerciser

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Abstract: Through comparison of Developmental Eye Movement (DEM) test, Virtual reality Head-mounted Display (VHD), DEM based on VR HMD system and existing DEM test (DEM), the effect of exercise on the dynamic visual acuity was examined. A total of 39 participants were analyzed through classification into ball sports group, aerobic exercise group, strength exercise group and non-exercise group. The experiments were performed in the order of DEM vertical test, DEM horizontal test, VHD vertical test and VHD horizontal test. There was no statistically significant difference between ball sports group and non-exercise group, between aerobic exercise group and non-exercise group and between strength exercise group and non-exercise group. The level of exercise performed by a regular person does not seem to affect the dynamic visual function. In the future, it will be necessary to analyze the correlation between exercise and dynamic visual function through the comparison experiment between the expert exercise group and the regular group.

Key words: Virtual reality, head-mounted display, dynamic visual acuity, developmental eye movement, exerciser, comparison

INTRODUCTION

Humans accept information from external environments through various senses. Among them vision is a higher sense than other senses and plays an important role in deriving or assisting other senses. Much of the way human beings acquire external information is communicated through visual information (Jarald, 2015). Visual function includes visual acuity to see things clearly, accommodation function of lens that focuses on circle/near object, binocular vision function to recognize single vision of objects through binocular vision and recognition of eyes and stereopsis, central vision seen when an object is on the retina, peripheral vision function that recognizes surrounding objects, the pursuit eye movement which is the ability to focus and follow moving objects and saccadic eye movement also known as a quick look and the ability to re-focus when things change.

Visual acuity is classified into static vision which measures the ability to see when the viewer and object are stationary and dynamic vision which measures the ability of the viewer or the object to see in motion (Hoffman *et al*., 1981). Dynamic vision plays an important role in driving a car or in sports that require constant body activity (Kohmura and yoshigi, 2004; Winson and Falkel, 2004) and is a key factor in determining athletic performance (Yi *et al*., 2000; Yi and Sin, 2005). Among the sports, dynamic sports are sports that require fast movement by maintaining the tension of the body every moment. It is very important to see accurately while moving but dynamic vision measurement system is not systematically established in the standard vision system. The study aimed to investigate the effects of exercise in regular people on dynamic vision through comparison between Virtual Reality Head-Mounted Display (VR HMD) system-based DEM test (VHD) inducing user movement and the existing DEM test (DEM).

MATERIALS AND METHODS

Experimental subjects: The subjects were selected from 39 people who had no ophthalmic, psychiatric or systemic diseases that were between the ages of 20~30 (average age 24.90±3.22), that had far/near sighted vision of over 0.8 who understood and agreed with the purpose of this study.

Test method: Before starting the experiment, the participants were checked for eye movement abnormality through the H-S scale (pursuit eye movement) (Kim, 2004)

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and factors affecting the body condition and the experiment through history review. Through exercise related questionnaire each subject was classified into ball sports group (football, basketball, badminton, kickball) 10 subjects, aerobic exercise group (jogging, walking, swimming) 9 subjects, strength exercise group (weight training) 8 subjects, overlap 4 subjects (ball+aerobic 1 subjects, ball+strength 1 subject, aerobic+strength 2 subjects) and non-exercise group 16 subjects. Exercise related questionnaire was performed by dividing the items by type, intensity, frequency and time of exercise. The order of experiment was DEM vertical test, DEM horizontal test, VHD vertical test, VHD horizontal test. In order to prevent fatigue an interval of 1 min was set between the DEM vertical test and the DEM horizontal test and between the VHD vertical test and the VHD horizontal test. VHD data were analyzed using an independent sample t-test of SPSS (Statistical Package for Social Science) and nonparametric analysis was used for a sample group of <30. At 95% confidence interval, $p<0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Comparison between ball exercise group and non-exercise group: Table 1 shows results of DEM and VHD between ball exercise group and non-exercise group. The DEM test results of the ball exercise group were vertical 23.11±3.46 sec, horizontal 21.46±4.26 sec, VHD test results were vertical 29.54±5.73 sec, horizontal 40.78±3.84 sec (Table 1; Fig. 1).

The DEM test results of the non-exercise group were vertical 21.72±3.28 sec, horizontal 19.57±4.32 sec, VHD test results were vertical 28.10±5.31 sec, horizontal 39.63±8.48 sec (Table 1; Fig. 1).

In all items, non-exercise group was measured faster than ball exercise group and statistical significance was not shown.

Comparison between aerobic exercise group and non-exercise group: Table 2 shows results of DEM and VHD between aerobic exercise group and non-exercise group. The DEM test results of the aerobic exercise group were vertical 20.51±2.91 sec, horizontal 19.16±2.29 sec, VHD test results were vertical 28.31±5.59 sec, horizontal 37.46±4.99 sec (Table 2; Fig. 2).

The DEM test results of the non-exercise group were vertical 21.72±3.28 sec, horizontal 19.57±4.32 sec, VHD test results were vertical 28.10±5.31 sec, horizontal 39.63±8.48 sec (Table 2, Fig. 2).

In the DEM vertical, DEM horizontal and VHD horizontal categories, the aerobic exercise group was measured faster than the non-exercise group and statistical significance was not shown.

Table 1: Comparison of DEM and VHD between ball exercise group and non-exercise group unit:sec

	Ball exercise group (n = 10)	Non-exercise group (n = 16)		
Variavbles	M±SD	M±SD	z-values	p-values
DEM verticality	23.11±3.46	21.72±3.28	-1.133	0.257
DEM horizontality	21.46±4.26	19.57±4.32	-1.239	0.215
VHD verticality	29.54±5.73	28.10±5.31	-0.474	0.635
VHD horizontality	40.78±3.84	39.63±8.48	-1.265	0.206

SD: Standard Deviation; Mann-Whitney U tes

Table 2: Comparison of DEM and VHD between aerobic exercise group and non-exercise group unit:sec

	Aerobic exercise group (n = 9)	Non-exercise group (n = 16)		
Variables	M±SD	M±SD	z	p-value
DEM verticality	20.51±2.91	21.72±3.28	-0.849	0.396
DEM horizontality	19.16±2.29	19.57±4.32	-0.340	0.734
VHD verticality	28.31±5.59	28.10±5.31	-0.057	0.955
VHD horizontality	37.46±4.99	39.63±8.48	-0.340	0.734

SD: Standard Deviation; Mann-Whitney U test

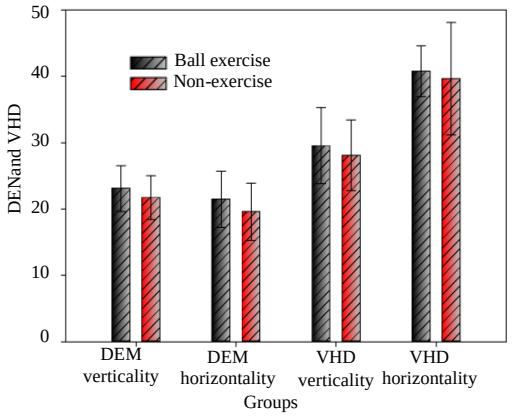

Fig. 1: Comparison of DEM and VHD between ball exercise group non-exercise group (*p<0.05)

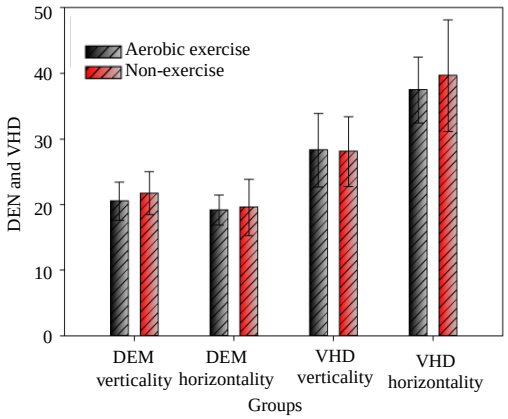

Fig. 2: Comparison of DEM and VHD between aerobic exercise group and non-exercise group (*p<0.05)

Table 3: Comparison of DEM and VHD between muscle exercise group and non-exercise group unit:sec

	Muscle exercise group (n = 8)	Non-exercise group (n = 16)		
Variables	M±SD	M±SD	z-values	p-values
DEM verticality	22.51±2.59	21.72±3.28	-0.735	0.462
DEM horizontality	19.59±2.76	19.57±4.32	-0.459	0.636
VHD verticality	28.33±4.36	28.10±5.31	-0.429	0.668
VHD horizontality	37.91±6.55	39.63±8.48	-0.184	0.854

SD: Standard Deviation; Mann-Whitney U test

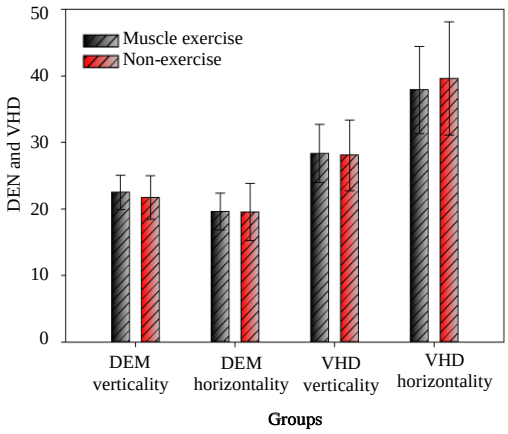

Fig. 3: Comparison of DEM and VHD between muscle exercise group and non-exercise group (*p<0.05)

Comparison between muscle exercise group and non-exercise group: Table 3 shows results of DEM and VHD between muscle exercise group and non-exercise group. The DEM test results of the muscle exercise group were vertical 22.51±2.59 sec, horizontal 19.59±2.76 sec, VHD test results were vertical 28.33±4.36 sec, horizontal 37.91±6.55 sec (Table 3; Fig. 3).

The DEM test results of the non-exercise group were vertical 21.72±3.28 sec, horizontal 19.57±4.32 sec, VHD test results were vertical 28.10±5.31 sec, horizontal 39.63±8.48 sec (Table 3; Fig. 3).

In the DEM vertical, DEM horizontal and VHD vertical items, the non-exercise group was measured faster than the muscle exercise group and no statistical significance was shown.

There was no consistent outcome in the comparison between the exercise groups and the non-exercise group and there was no statistically significant difference. Dynamic sports require excellent binocular vision and are capable of improving functions through sports vision training similar to the physical exercise system due to the nature of visual system. As a result, there are visual training programs to improve sports performance (Erickson *et al*., 2007; Wood and Aberethy, 1997). In the present experiment, it was hypothesized that the training effect of the visual system in the exercise group would make the VHD speed faster but there was no consistent flow or significant difference in comparison with the non-exercise group. This suggests that the level of ball sports activity, aerobic activity and strength training activity performed by regular people do not affect dynamic visual ability.

CONCLUSION

Humans move their eyes first before they see or act on an object. Dynamic vision which works to recognize objects clearly while moving is a very important function in life. Unlike static vision, dynamic vision does not have a standardized measurement system and its importance is not recognized. Among dynamic vision, the pursuit eye movement is closely related to the reading performance and therefore it is an important visual function for school children and adults.

In VR, motion sickness is one of the main problems requiring solutions. When using this as vision training, it is necessary to propose a reasonable time to use VHD by verifying the manifestation symptoms of each time period. It is also expected to add interesting storytelling to the content to increase the interest and test effect. It is determined that the correlation between exercise and dynamic vision and training effect should be verified through comparative experiment between expert exercise group and non-exercise group.

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