The Ocular effects of Virtual Reality Headset in Teenagers

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Keywords: Virtual reality headset, Ocular effect, Vision measurement procedure

ABSTRACT

In this study, the vision measurement procedure is used to determine the discomfort of using VR headset. As the analyzed results shown, diopter (D), amplitude of accommodation (A.A), intraocular pressure (IOP) and stereopsis are helpful to check the ocular effect of teenagers with VR headset. According to this procedure, it can provide an essential basis for preventing fatigue and discomfort caused by VR using in teenagers.

1 Introduction

Since Google launched Google Cardboard (mobile phone type) in 2014, you can experience the effects of virtual reality (VR) at a low cost, which is the key to accelerate the population of VR. Because of its low cost and easy portability, it has driven the development of the entire VR market.

Electronic entertainment by teenagers has caused excessive eye use, leading to increased myopia and related diseases of the eyes. Myopia is the type of refractive error with the highest incidence in the world today. The prevalence rate of myopia in adolescents in some Asian areas can reach more than 70% [1].

Therefore, as VR is gradually emerging, this research aims to solve accommodation conflict, image relay, and motion fatigue encountered by VR headsets and proposes the measurement procedure. We measure the diopter, amplitude of accommodation, intraocular pressure and stereopsis of the eyes to determine the ocular effect when using a VR headset.

2 Experiment.

2.1 Subjects

One hundred and three healthy subjects (48 males and 55 females, 16.93±1.40 years old) will participate in this study, and they have to sign the experimentally informed consent including experimental procedures, precautions, and personal information. The subjects must have regular sleep schedules and be prohibited from consuming any substances that contained caffeine or alcohol 8 hours before the experiment. The subjects must have slept for 8 hours the night before the experiment and had no visual dysfunction or cardiovascular diseases.

2.2 Experimental environment

In order to simulate the situation where the subjects are watching 3D videos while wearing VR headset, the test site of this research is a bright room, and the indoor temperature is controlled at 25±2℃ [2]. The VR headset is (VRTRID VR-headset D601), and its specification is shown in Table1.

Table.1 The specification of VR device

	Smartphone size from 4.7”-6”
	Width 82mm and Max length 157mm.
	Field of view (FOV) 120°
	Size 194 * 129.5* 109.5mm

2.3 Experimental procedure

When wearing a VR headset, the distance between the screen and the eyes is very close (15cm), which will cause pupil shrinkage, contraction of human ciliary muscles, expansion of the lens, and the converging and spreading movements of the extraocular [3]. Since pupil shrinkage and enlargement are part of the mechanism of aqueous humor circulation to control intraocular pressure, the contraction of the ciliary muscle and the expansion of the lens will change the diopter and accommodation of the eye and the convergent and diffusive ability of the extraocular muscles will affect the comfort of the eye. Therefore, this experiment will measure the eye's diopter, the amplitude of accommodation, intraocular pressure and stereopsis as essential factors in the study of comfort when wearing a VR headset.

In this study, all subjects were put on +3.00D glasses to perform the relaxation adjustment with the fogging method for 5 minutes before starting the process [4]. The subject wears a VR headset to watch a 7-minute 3D movie, the content is shown in Fig. 1. Before and after the movie, the diopter, accommodation, and intraocular pressure of the eyes will be measured. The experimental procedure is shown in Fig. 2. The optometrist used in this study is the SHIN-NIPPON K5001 automatic optometrist to measure refractive errors and amplitude of accommodation (AA). The NIEDEK NT-2000, a non-contact intraocular pressure meter (NCT) to measure the intraocular pressure (IOP). The Randot stereoscopic test is used to measure the stereoscopic and disparity angle, as shown in Fig. 3.

Fig. 1 3D video content in VR headset

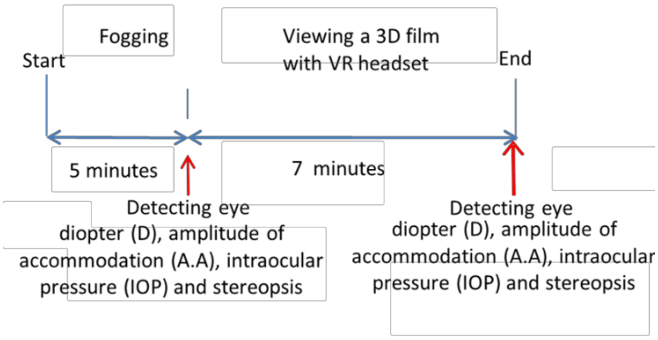

Fig. 2 Flow charts of the experiment

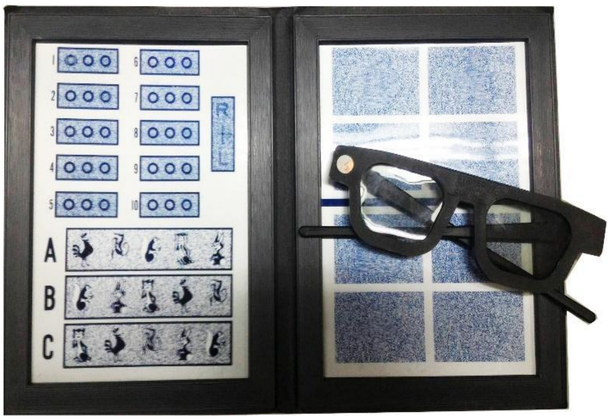

Fig. 3 Randot stereoscopic test

2.4 Statistical analysis

Stat v2.03(SPSS) is utilized in this study to analyze the diopter, accommodation, and intraocular pressure after watching a VR video. Pair t-test is used for the within statistics, and the statistical analysis proceeds with the significance of 0.05.

3 Results

3.1 Diopter check

The average diopter of the right eye was -2.59 D, and the average diopter of the left eye was -2.93 D before using VR headset. After using VR headset, the average diopter of the right eye is -2.94 D, and the average diopter of the left eye is -3.14 D. There is no statistical difference in diopter analysis, as shown in Table.2 and Fig.4.

Table.2 The average diopter (D) before/after using VR headset

Unit：Diopter (D)

	Before	After	P-value
average diopter of right eye	-2.59±2.30	-2.94±2.23	0.28
average diopter of left eye	-2.93±2.20	-3.14±3.09	0.20

* $p < 0.05$

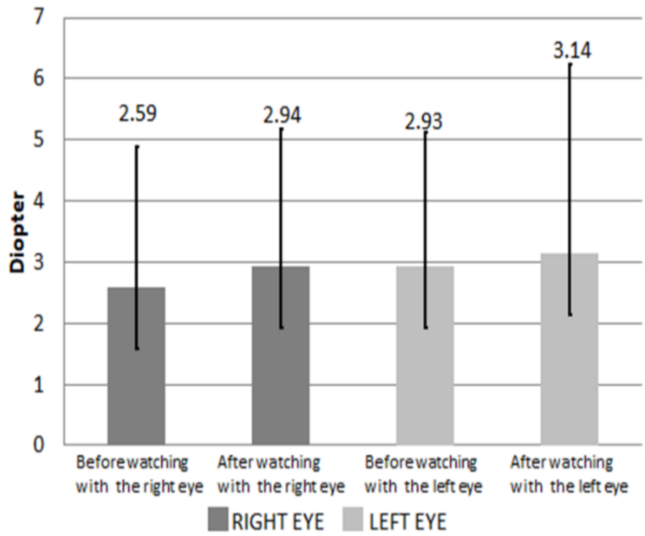

Fig. 4 The results of eyes diopter (* $p < 0.05$)

3.2 Average amplitude of accommodation check

The average amplitude of accommodation (A.A) of the right eye was 7.08 D, and the A.A of the left eye was 6.89 D before using VR headset. After using VR headset, the A.A of the right eye is 7.34 D, and the A.A of the left eye is -7.61 D. The experimental results show an increase and the P-value of the left and right eyes are both less than 0.05, there is a statistical difference, as shown in

Table. 3 and Fig. 5.

Table.3 The average amplitude of accommodation (A.A) before/after using VR headset

Unit：Diopter (D)

	Before	After	P-value
average amplitude of accommodation of right eye	7.08±2.38	7.34±2.43	0.05*
average amplitude of accommodation of left eye	6.89±2.77	7.61±2.37	0.002*

* $p < 0.05$

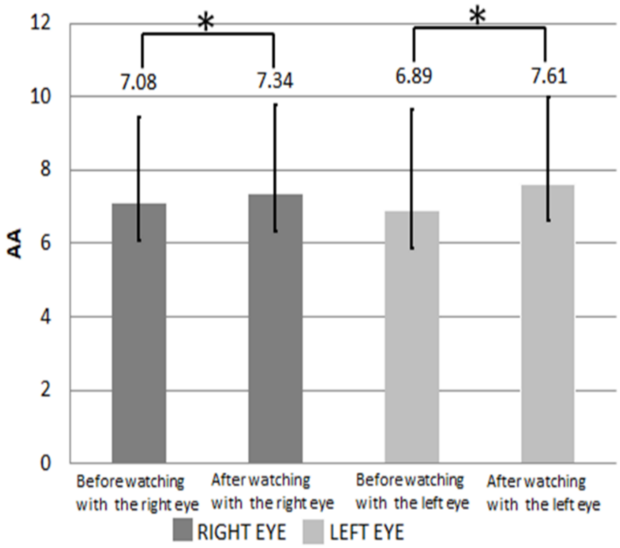

Fig. 5 The results of eyes amplitude of accommodation (* $p < 0.05$)

3.3 Intraocular pressure check

The average intraocular pressure (IOP) of the right eye was 16.01 mmHg, and the A.A of the left eye was16.32 mmHg before using VR headset. After using VR headset, the A.A of the right eye is 16.32 mmHg, and the A.A of the left eye is 15.85 mmHg. The experimental results show an increase and the P-value of the left and right eyes are both less than 0.05, there is a statistical difference, as shown in Table. 4 and Fig. 6.

Table.4 The average intraocular pressures (IOP) before/after using VR headset

Unit：mmHg

	Before	After	P-value
average intraocular pressures of right eye	16.01±3.65	15.77±2.98	0.049*
average intraocular pressures of left eye	16.32±2.96	15.85±2.79	0.037*

* $p < 0.05$

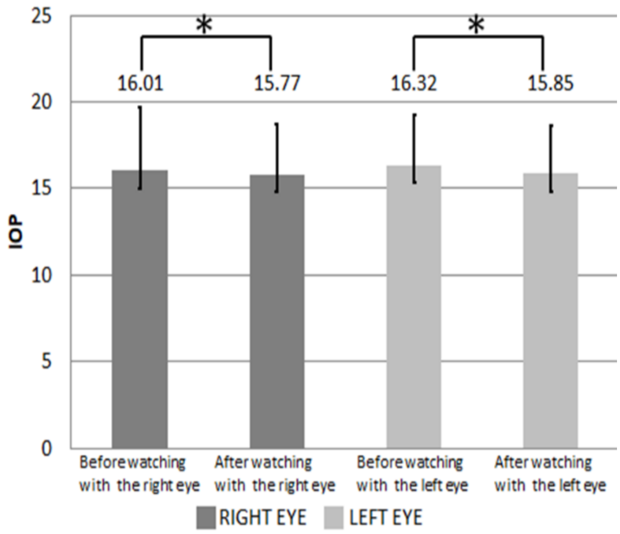

Fig. 6 The results of eyes IOP (* $p < 0.05$)

3.4 Stereopsis check

The average stereopsis of both eyes was 69.80 arc/sec before using VR headset. After using VR headset, the average stereopsis of both eyes was 57.23 arc/sec. The experimental results show the better stereopsis and the P-value is less than 0.05, there is a statistical difference, as shown in Table. 5 and Fig. 7.

Table.5 The average stereopsis of both eyes before/after using VR headset

Unit：arc/sec

	Before	After	P-value
average stereopsis of both eyes	69.80±60.87	57.23±40.98	0.004*

* $p < 0.05$

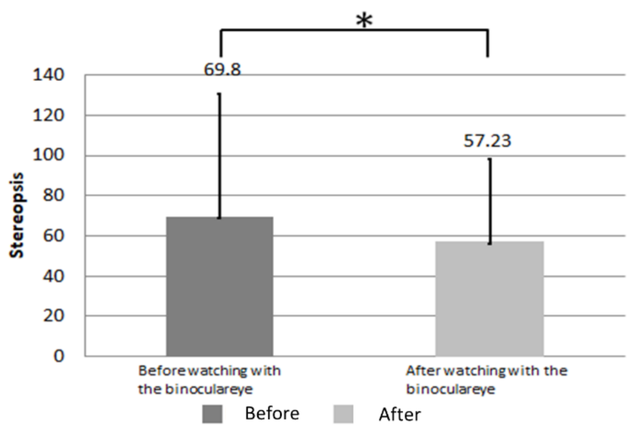

Fig. 7 The results of eyes stereopsis (* $p < 0.05$)

4 Discussion

As the result of diopter, the diopter changes of the two eyes before and after using VR headset have a rising trend, but there is no statistical difference. As the result of the A.A, the A.A changes of the two eyes before and after using VR headset have a rising trend, and the P-value is less than 0.05. There is a statistical difference. The screen of the VR headset is very close to the human eyes, so there will occur the near-reflex triad. It will increase A.A and convergence [3].

The screen of the VR headset is very close to the human eyes, so there will occur the phenomenon of pupil constriction [5]. It will cause the near-reflex triad [6], and it will increase A.A and convergence [3]. The experimental results also show it decreased intraocular pressure when using a VR headset to watch the 3D video. The increasing distance between the anterior chamber of the eye and the even-angle sieve [7], which is more conducive to the flow of aqueous humor into Schlemm's canal [8]. When the aqueous channel is smooth, the intraocular pressure will naturally decrease [9]. It is well understood that same parasympathetic innervation of both sphincter muscle of iris and ciliary muscle. Any activity that activate mitosis will also trigger ciliary muscle contraction that enhance sclera spur tension. And it will enlarge the trabecular meshwork opening [10]. Finally, due to increased aqueous flow, the IOP will decrease.

Comparing stereopsis before and after using VR headset shows that stereopsis is improved, and the P-value is less than 0.05, which is significant different. After using VR headset, people will adapt to 3D content, and the stereopsis will be enhanced [11.12].

5 Conclusions

In this study, the vision measurement procedure is used to determine the discomfort of using VR headset. We measure diopter, A.A, intraocular pressure and stereopsis to check the ocular effect of teenagers with VR headset. This result can provide an essential basis for preventing fatigue and comfort caused by VR using in teenagers. Moreover, to provide experts with the use of physiological parameters as a reference when formulating safety regulations for VR devices.

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