Reducing the Discomfort of Watching 3D Videos with Progressive Addition Lenses

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Keywords: 3D discomfort reducing, Progressive Addition Lenses, 3D videos

ABSTRACT

In this study, the different optical powers of progressive addition lenses (PAL) are used to correct the amplitude of accommodation, which can help for reducing the discomfort of watching 3D video for a long time. As the analyzed results shown, before watching 3D movies, the average amplitude of accommodation (AA) of the right eye is 12.36D and the average AA of the left eye is 12.25D. After watching a 3D video with PAL, the average AA of both eyes are reduced to 11.51D. As the results shown, while watching 3D videos with PAL can cause human's eyes pressure to drop and prevent the eye fatigue.

1 Introduction

Watching 3D movies is often accompanied by symptoms such as discomfort, vomiting, dizziness, and asthenopia [1-3]. According to the study [4], because the light sources of parallax 3D image falls on the flat screen, but human's brain has a three-dimensional spatial sense that can move positive, zero, negative parallax, will cause cognitive conflict, the mechanism of the near reflex of ocular muscles are also destroyed, resulting in the asthenopia and dizziness [5]. In this study, PAL with different optical powers is proposed to relax accommodation, including to reduce amplitudes of accommodation and intraocular pressure (IOP), so as to lower the discomfort caused by crystal tightening when watching 3D videos [6].

2 Methods

PALs are often applied on relaxing accommodation when people view different distance from far to near. The specifications of the PALs used in our study ranged from top to bottom include 4 kinds of optical powers such as 0.25D, 0.50D, 0.75 and 1.00D. The same subjects were first asked to watch 3D films and recorded changes in physiological parameters of their accommodation and intraocular pressure. Then ask them to wear PALs to watch the same content of 3D film, also recorded the changes of their data of accommodation and intraocular pressure. See if it reduces user's discomfort when watching 3D movies.

3 Experiment

The subjects of this study were 15 visually impaired persons above 1.0 (Visual Acuity), with an average age of 22.6 ± 2.3 years, 10 men and 5 women, each subject must have adequate sleep before being tested, do not eat foods containing caffeine and alcohol for 8 hours prior to the trial, and have understood the experimental process of this study.

15.6-inch Naked-eye 3D Display is used as an image source for 3D movies, with the distance between the subject's seat and the screen fixed at 60cm. As shown in Figure 1. 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).

There are two experimental groups organized in this study, one is 3D and another is 3D with PAL. Each subject was tested twice at one-week intervals. The experimental flow is shown in Figure 2. Stat v2.03 (SPSS) statistical software is used for analyzing AA and IOP.

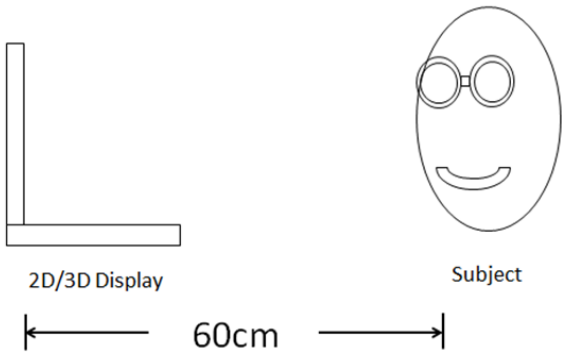

Fig. 1 Flow charts of the experiment

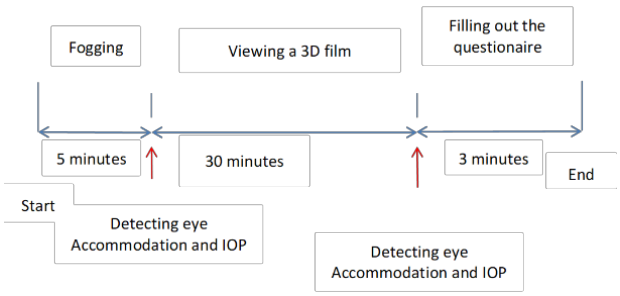

Fig. 2 Flow charts of the experiment

4 Results

4.1 Eye accommodation examination

The results of AA checked before and after viewing a 3D video are shown in Table 1 & Figure 3. It can be found that the average AA of both the left and right eye decreased compared to the values before and after watching the movie, and the results show that they have significant differences (right eye P=0.024; left eye P=0.001). As the results of AA measured from the group of watching 3D movies with PAL were shown in Table 2 & Figure 4. It is found that there is no significant difference.

Table.1 The average amplitude of accommodation (AA) before/after watching 3D movies

Unit：Diopter (D)

	Before watching 3D movies	After watching 3D movies	P-value
Average AA of right eye	12.91±2.43	11.57±1.13	0.024*
Average AA of left eye	13.07±1.04	11.48±1.35	0.001*

* $p < 0.05$

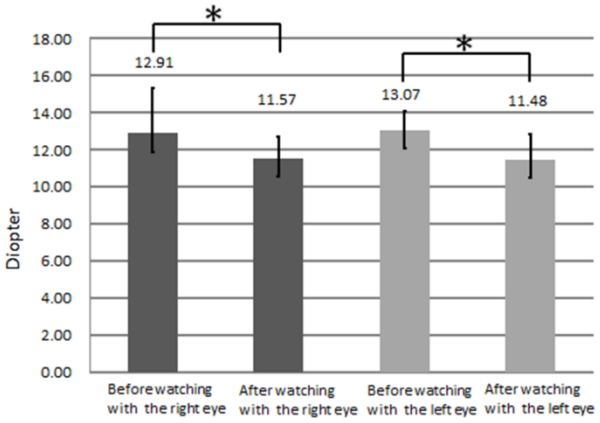

Fig. 3 Amplitude of accommodation (AA) before/after watching 3D movies (* $p < 0.05$)

Table.2 The average amplitude of accommodation (AA) before/after watching 3D movies with progressive addition lenses

Unit：Diopter (D)

	Before watching 3D movies	After watching 3D movies	P-value
Average AA of right eye	12.36±1.46	11.51±2.02	0.07
Average AA of left eye	12.25±1.67	11.51±2.36	0.06

* $p < 0.05$

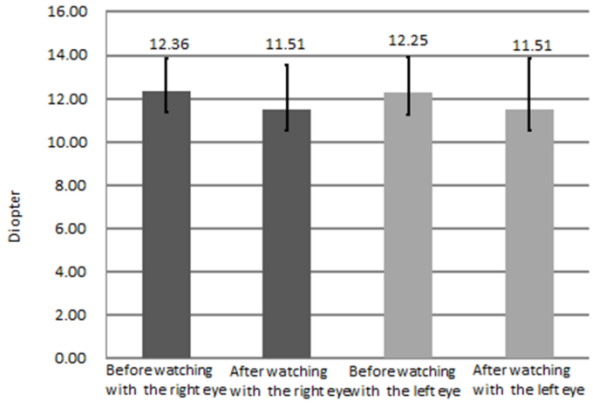

Fig. 4 Amplitude of accommodation (AA) before/after watching 3D movies with PALs (* $p < 0.05$)

4.2 Intraocular pressure check

The Intraocular pressure (IOP) of the 3D group's check before and after watching the 3D film are shown in Table 3. There is significant difference in the average IOP at the right eye (p = 0.01). The results of the 3D with PAL group in the eye pressure (IOP) measurement before and after watching the 3D film are shown in Table 4. The average IOP in both the left and right eyes decreased compared to the values before and after watching the movie with statistically significant difference (right eye p = 0.01; left eye p = 0.01). In order to effectively evaluate the effect of PAL on watching 3D movies, the initial physiological values of the subjects were used as a reference benchmark, the results of the post-test were subtracted from the pre-test results, and the difference was divided by the initial value, so as to obtain the rate of change of physiological state after watching the 3D film. We put the results of the 3D group and the 3D with PALs group together as shown in Table 5. As the statistical results, there was a significant difference between wearing and not wearing (right eye p

< 0.01; left eye $p < 0.01$). The results showed that the IOP decreased in both eyes of the subjects compared to the without PALs groups who watched 3D films after wearing PALs.

Table.3 The average intraocular pressures (IOP) before/after watching 3D movies.

Unit：mmHg

	Before watching 3D movies	After watching 3D movies	P-value
Average IOP of right eye	12.13±2.70	10.27±2.32	0.01*
Average IOP of left eye	10.87±2.73	10.87±2.69	0.45

* $p < 0.05$

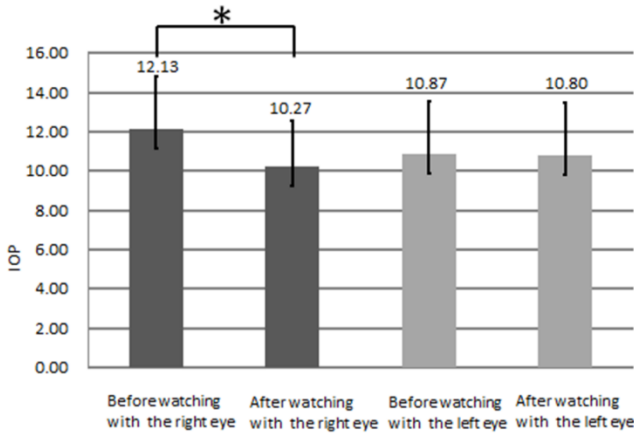

Fig. 5 Intraocular pressures before/after watching 3D movies (* $p < 0.05$)

Table.4 The average intraocular pressures (IOP) before/after watching 3D movies with progressive addition lenses

Unit：mmHg

	Before watching 3D movies	After watching 3D movies	P-value
Average IOP of right eye	11.06±3.48	10.27±2.91	0.01*
Average IOP of left eye	11.27±2.26	10.07±2.08	0.01*

* $p < 0.05$

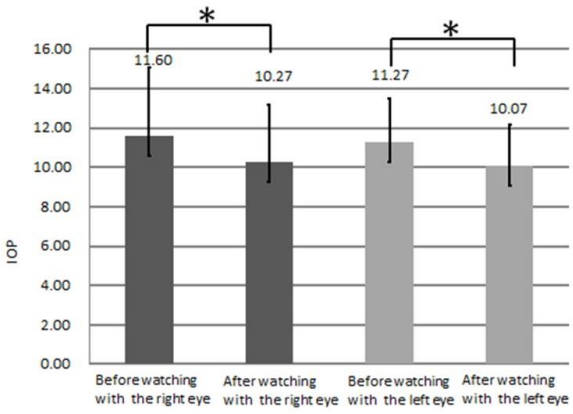

Fig. 6 Intraocular pressures before/after watching 3D movies with PALs (* $p < 0.05$)

Table.5 The difference of IOP after watching 3D movies compared between 3D and 3D with PALs groups

Unit：mmHg

	3D group	3D with PALs group	P-value
Difference of right eye IOP	0.14±0.13	0.11±0.09	< 0.01*
Difference of left eye IOP	0.17±0.10	0.16±0.10	< 0.01*

* $p < 0.05$

4.3 Questionnaires

Subjects were asked to fill out a questionnaire assessment as an indicator of asthenopia after receiving experiments in 3D and 3D with PALs groups. After watching the film, it was found that the subjects in 3D groups compared to the 3D with PALs groups more likely to feel images blur, feel uncomfortable, asthenopia and feel dizzy. Analyzed results of the questionnaire for 3D groups and 3D with PALs groups are shown in Table 6.

Table.6 The results of the questionnaire compared between 3D and 3D with PALs groups

	3D group	3D with PALs group	P-value
1. Meets the best distance you can see	4.47±0.50	4.27±0.77	0.17
2. The image is blurry	3.80±0.54	3.00±0.89	0.00*
3. More attention is needed	3.37±0.77	3.53±0.96	0.29

4. Feel impatient	4.20±1.22	3.87±1.20	0.22
5. Feel uncomfortable	4.13±1.31	3.27±0.77	0.03*
6. The eyes are tired	4.27±1.18	3.40±0.80	0.04*
7. Feel dizzy	3.47±1.31	2.87±1.02	0.05*
8. feel a headache	2.33±0.87	2.27±0.57	0.39

* $p < 0.05$

5 Discussion and conclusions

The PALs gradually reduces its optical power from the remote to near-use area, so that it can provides a gradually varied visual space from far to near distance and it could meet the needs of the subject at various distances to clearly see objects, and reduce the accommodation in watching object from far to near distances. Thereby reducing the phenomenon of retinal defocusing. According to several studies, the use of different optical powers of progressive addition lenses can reduce the using rate of accommodation activity [7-9]. Therefore, in this study, PALs is used to help for watching 3D movies, through the measurement and analysis of accommodation, the results show that before watching 3D movies the average AA of the right eye ranges of 12.36D, and the AA of the left eye ranges of 12.25D. And the result of using PALs to watch 3D movies, the after AA of the eyes is about 11.51D. It shows that wearing PALs to watch 3D movies only need some tuning, then it can reduce the discomfort of the eyes.

In medical, the rising of intraocular pressure (IOP) is often caused by poor drainage of aqueous humor, and the normal range of IOP is about 10 to 20 mmHg. The results showed that after the subjects wore PALs to watch 3D films, the IOP decreased significantly, with the right eye pressure decreasing by 7.1% and the left eye pressure decreasing by 10.6%. Comparing the IOP differences of watching 3D movies in 3D group and 3D with PALs group, there were significant decreasing between the IOP differences for both the left and right eyes. As the result, it is found that wearing PALs can avoid the IOP increasing caused by watching 3D movies and reduce eye discomfort. The reason why the descent of IOP happened is caused by the narrowing of the pupils and the rapid outflow of aqueous humor to the outside of the eye. Regarding the results of the questionnaires, it is found that wearing PALs to watch 3D movies does not feel images blurred, and without discomfort, dizziness and asthenopia. It shows that while the subjects watching 3D movies wearing PALs can improve the eye fatigue. It is well understood that same parasympathetic inner action 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.

To sum up, using PALs with different optical powers to correct the AA of eyes is indeed able to relax our eyes' accommodation and prevent the rising of IOP, and also able to reduce the discomfort of eyes while audience watching a 3D video.

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