Kawasaki Journal of Medical Welfare Vol. 24, No. 1, 2018 9－16

Original Paper

Evaluation of Asthenopia Caused by Game Consoles

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(Accepted June 25, 2018)

Key words: Wii U, asthenopia, near point, high frequency component, questionnaire survey

Abstract

A visual function test and a questionnaire survey on asthenopia were performed before and after the use of a game console and compared to clarify the influence of the use of a game console on the visual function and asthenopia of healthy young people. The subjects were 20 healthy young persons aged 20.0 ± 0.5 years (17 females and 3 males). The near point, the rate of high frequency component (HFC) of accommodative microfluctuation, and lacrimal secretion were measured and an original questionnaire survey on asthenopia was performed before and after carrying out a task using a game console. The task was continuous playing of an action race game, 'MARIOKART 8' (Nintendo) using Wii U (Nintendo), for 2 hours at a visual distance of 170 cm. The near point was 11.86D before the task and it significantly extended to 10.98D after the task ($p < 0.05$). The rates of HFC of the dominant eye before and after the task were 13.3 and 8.6%, respectively. Those of the non-dominant eye were 8.4 and 8.2%, respectively. And the lacrimal secretions were 21.2 and 21.0 mm, respectively. All the tasks showed no significant changes after each task in any parameter. The score of the subjective questionnaire survey was 14.6 before the task and it significantly increased to 34.8 after the task ($p < 0.05$). The task of continuous 2-hour operation of the game console significantly extended the near point and caused subjective fatigue.

1. Introduction

With the recent spread of laptop computers, smartphones, tablets, and game consoles, the frequency of staring at a close distance for a prolonged period has increased. Near vision work with staring at a close distance for a prolonged period induces excessive tension of accommodation, being the cause of disease associated with asthenopia such as Information Technology Ophthalmology, Visual Display Terminal syndrome, and technostress ophthalmopathy. Moreover, cases of strabismus induced after watching a 3-dimensional (3D) movie have been reported[1,2)], and the influence of game consoles on the body is of concern. Studies in which asthenopia was evaluated by performing subjective and objective visual function tests before and after viewing a 3D video have been performed[3-5)].

The history of game consoles began in the 1970s, and 53.26 million people had a game console in 2016[6)].

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Wii U (Nintendo) was released in 2012, and 'Wii U MARIOKART 8' (Nintendo)' is the action game most sold in Japan, being played by many people.

In this study, an action race game using a game console was presented, a task of continuously playing it for 2 hours was set, and the parameters were investigated before and after carrying out the task. Significant findings were observed in the visual function and asthenopia.

2. Methods

2.1 Subjects

The subjects were 20 young healthy persons (40 eyes) (17 females and 3 males) aged 20-23 years old (mean: 20.0 ± 0.5 years old) with no eye disease other than ametropia who gave consent to the test. The mean refract as spherical equivalent was -1.51 ± 1.38 Diopter (D). Far visual acuity was 1.0 or higher in all subjects. The task of continuously playing 'Wii U MARIOKART 8' was performed under complete refractive correction.

The objective of the study was sufficiently explained to the subjects and written consent was obtained. The subjects could immediately withdraw from the test when they wanted even after giving consent to cooperation. This study was approved by the Ethics Committee of the Department of Sensory Science, Faculty of Health Science and Technology, Kawasaki University of Medical Welfare (approval number: 2015-1).

2.2 Procedures

2.2.1 Task environment

The devices used in this experiment were Wii U GamePad (Nintendo) and Wii U-exclusive software 'MARIOKART 8' (Nintendo) (Figure 1). For presentation of the video, a 46V display, AQUOS LC-46W9 (SHARP), was used. Since the optimum viewing distance is 'about 3 times of the height of the screen', the viewing distance was set at 170 cm calculated from the height of the display. For the chair during viewing, a manager chair (JOINTEX) was used, and its height was set corresponding to the level of the subject's eye line. The dominant eye was determined using the hole-in-card test. Since it has been reported that the high frequency component of the dominant eye is significantly higher than that of the non-dominant eye[7], each subject's dominant eye was determined and the rates of the high frequency component of the dominant and non-dominant eyes were investigated.

Figure 1 Carrying out the task using the game console

2.2.2 Viewing environment

According to the National Time Use Survey, 'the mean hours used for hobbies, entertainment, and culture', including playing video games, vary depending on weekday or Sunday, sex, and generation, but the most frequent and longest time was 2 hours or longer but shorter than 3 hours[8]. Thus, the duration of the task using the game console was set at 2 hours. A visual function test and a questionnaire survey were performed before and after carrying out the task.

2.2.3 Visual function test

In the visual function test, the near point, the rate of HFC, and lacrimal secretion were measured before and after the task.

(1) Near point

The near point was measured using a near vision response measurement device, TriIRIS® C9000 (TriIRIS) (Hamamatsu Photonics K.K.). TriIRIS is a diagnostic device cooperatively developed by Hamamatsu Photonics K.K. and Wac, and it is capable of evaluating asthenopia and abnormal accommodative function. TriIRIS presents an actual optotype for the bilateral open eyes, and the near vision response can be objectively measured and recorded in a state close to everyday vision[4,9]. The subjective near point with both eyes open was measured using TriIRIS. The accommodation optotype was moved, going and returning 3 times at a constant refraction rate between the far point and a site 1D near from the near point of each subject. The near point was measured 3 times in each subject and the mean was calculated.

(2) HFC of accommodative microfluctuation

Accommodative microfluctuation was measured using an autorefractometer, Speedy-K®, and an accommodative microfluctuation analysis program, Version Mi-crofluctuation-1® (MF-1) (RIGHT GROUP). The high frequency component (HFC), which is the mean power spectrum of the 1.0-2.3 Hz frequency region calculated by Fourier Transform, was evaluated. Regarding the experimental condition, the optotype position was set at +0.5 to -3.0D in 8 steps at every 0.5D based on the objective spherical equivalent, and the duration of presenting the optotype was 10 seconds at each position[7]. The rate of occupation by HFC was presented as %.

(3) Lacrimal secretion

Lacrimal secretion was measured in each eye before and after the task using the phenol red thread tear test[10]. It was presented as the length (mm) of phenol red thread with color change.

2.2.4 Survey of subjective asthenopia

Asthenopia was surveyed using a questionnaire. The questions in the awareness survey were prepared based on the items of a subjective symptom questionnaire prepared by Hosohata et al.[11]. It was comprised of 10 questions concerning the eyes and 10 questions concerning physical symptoms (20 questions in total), in addition to asking the refractive correction method to play games and show the history of the use of Wii U. Seven choices were prepared for the answer to the awareness survey and scored as follows: 'I feel it very strongly', 6 points; 'I feel it strongly', 5; 'I feel it slightly strongly', 4; 'I feel it', 3; 'I slightly feel it', 2; 'I faintly feel it', 1; and 'I do not feel it', 0. The questionnaire survey was performed before and after the task and the total score of the items was calculated.

2.2.5 Statistical analysis

The Wilcoxon signed rank test and paired t-test were used, and a significance level below 5% was regarded as significant.

3. Results

3.1 Changes in the visual function

The near point and the rates of HFC of the dominant and non-dominant eyes and lacrimal secretion are presented below as the visual function test results before and after the task.

3.1.1 Near point

The mean ± standard deviation (SD) of the near point of the subjects was 11.86 ± 0.65D (median: 12.15D) before the task. After the task, it became 10.98 ± 1.34D (median: 11.00D), showing that the near point significantly extended after the task ($p<0.05$) (Figure 2).

3.1.2 HFC of accommodative microfluctuation

The mean ± SD of the rate of HFC of the dominant eye was 13.3 ± 17.4% (median: 4.3%) before the task and 8.6 ± 14.7% (median: 4.2%) after the task, showing no significant change (p=0.433) (Figure 3). Those of the non-dominant eye were 8.4 ± 7.9% (median: 7.6%) and 8.2 ± 8.5% (median: 4.2%), respectively, showing no significant change (p=0.453) (Figure 4). The dominant eye was right in 11 subjects (55%) and left in 9 subjects (45%).

3.1.3 Lacrimal secretion

The mean ± SD of lacrimal secretion of the 20 subjects (40 eyes) was 21.2 ± 5.5 mm (median: 21.0 mm) before the task and 21.0 ± 6.2 mm (median: 21.0 mm) after the task. No significant difference was noted in lacrimal secretion between before and after the task (p = 0.869) (Figure 5).

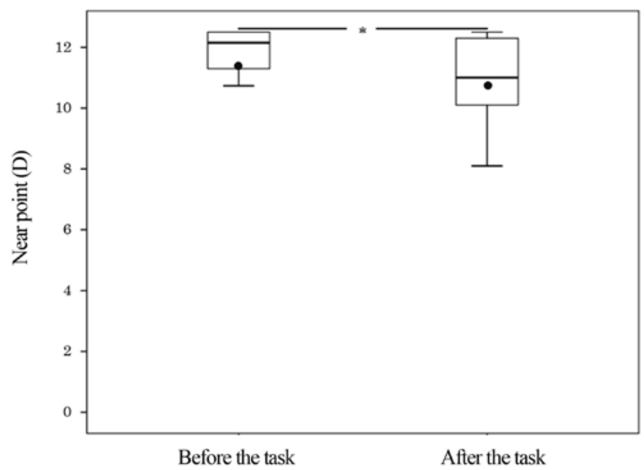

Figure 2 Box-and-whisker plots showing the median measured near point on TriIRIS before and after the task (n = 20). Each box shows the 75th percentile (top) and 25th percentile. The closed circles inside the box represent the mean and the horizontal line inside the box represents the median (50th percentile). A significant difference was noted after the task (*p < 0.05, paired t-test).

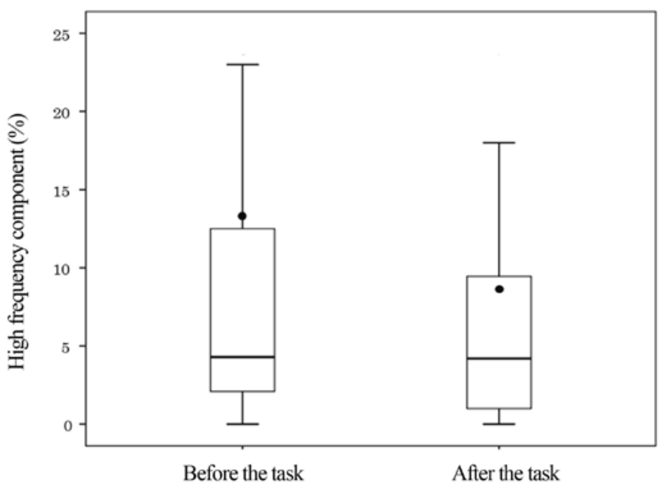

Figure 3 Box-and-whisker plots showing the median measured high frequency component of accommodative microfluctuation before and after the task in the dominant eye (n = 20). Each box shows the 75th percentile (top) and 25th percentile. The closed circles inside the box represent the mean and the horizontal line inside the box represents the median (50th percentile). No significant difference was noted between before and after the task (p = 0.433, Wilcoxon signed rank test).

3.2 Results of questionnaire survey on subjective asthenopia

The total scores of the selection questionnaire of each subject before and after the task were calculated and summed. The mean ± SD of the score was 14.6 ± 11.7 (median: 12.0) before the task and 34.8 ± 19.6 (median: 34.5) after the task. The score significantly increased after the task ($p < 0.05$) (Figure 6).

4. Discussion

Changes in the visual function and asthenopia caused by continuously performing the task using the game console for 2 hours were investigated by comparison of these between before and after the task to

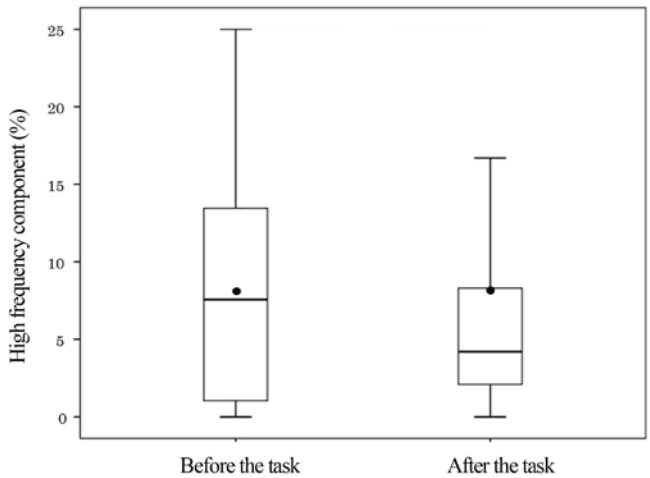

Figure 4 Box-and-whisker plots showing the median measured high frequency component of accommodative microfluctuation before and after the task in the non-dominant eye (n = 20). Each box shows the 75th percentile (top) and 25th percentile. The closed circles inside the box represent the mean and the horizontal line inside the box represents the median (50th percentile). No significant difference was noted between before and after the task (p = 0.453, Wilcoxon signed rank test).

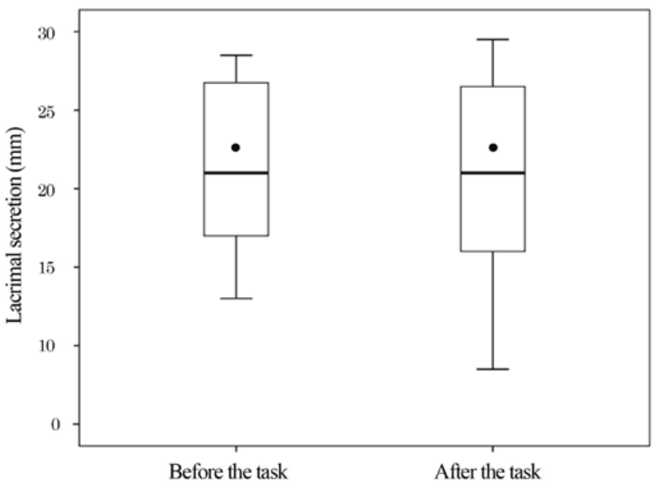

Figure 5 Box-and-whisker plots showing the median measured lacrimal secretion before and after the task (n = 40). Each box shows the 75th percentile (top) and 25th percentile. The closed circles inside the box represent the mean and the horizontal line inside the box represents the median (50th percentile). No significant difference was noted between before and after the task (p = 0.869, paired t-test).

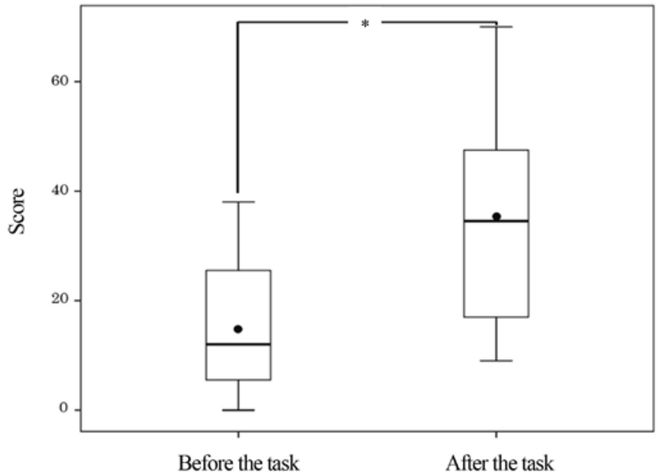

Figure 6 Box-and-whisker plots showing the median measured score in the subjective questionnaire result before and after the task (n = 20). Each box shows the 75th percentile (top) and 25th percentile. The closed circles inside the box represent the mean and the horizontal line inside the box represents the median (50th percentile). A significant difference was noted after the task (*$p < 0.05$, paired t-test).

clarify the influence of playing the game in healthy young people.

The near point significantly extended after continuously performing the task for 2 hours. Of the 3 elements of near vision response: miosis, accommodation, and convergence, miosis and near positive accommodation are controlled by the parasympathetic nerve. The resting state of accommodation is a state with balanced tension between the sympathetic and parasympathetic nervous systems of the eyes, and it is considered to be the accommodation level of a non-stimulated state[12,13]. Extension of the near point may have been due to reduction of parasympathetic nerve activity and a relative increase in the sympathetic nerve activity caused by staring at the character in the game console for a prolonged period.

No significant difference was noted in the HFC value of accommodative microfluctuation between before and after the task in either the dominant or non-dominant eye. Accommodative microfluctuation is derived from vibration of the ciliary muscle. Its HFC value represents an excessive load on the ciliary muscle, and the frequency of the high frequency component increases in cases of accommodation spasm and tonic accommodation compared with that in normal cases[14]. Accordingly, it was considered that no excessive load, such as accommodation spasm or tonic accommodation, was burdened on the ciliary muscle in the subjects after the task.

Based on the fact that the functional role of accommodative microfluctuation is detection of blurring of retinal images[15], it has been reported that the HFC value of near-sighted eyes is likely to be high[3]. However, the spherical equivalent of the subjects was emmetropia to mild-moderate myopia, which may have resulted in the absence of a significant difference in the HFC value between the dominant and non-dominant eyes.

The mean lacrimal secretion was within the normal range before and after the task, and no significant difference was noted between the bilateral eyes or between before and after the task. It has been reported that incidences of asthenopia and dry eye increase when refraction is not appropriately corrected[16]. However, since the subjects were young and healthy and refraction was corrected appropriately for the environment, no significant change was noted after the task, which may have resulted in no changes in lacrimal secretion.

The score of the questionnaire survey after the task was significantly higher than that before the task. Individual subjective intervention is large in questionnaire surveys, and the judgment criteria may have varied among the subjects. Development of fatigue is related to unbalance between the parasympathetic and sympathetic nervous systems of the iris sphincter, pupillary dilator, and ciliary muscle, which are related to near vision response, and relations of the functions of the central nervous system and cerebral cortex have been reported[17]. In this study, because of eye movements due to convergence, it was difficult to accurately record the pupil over time, therefore we did not use pupil movement as an index. Taking this into consideration, pupil findings appeared to show no obvious abnormalities in all subjects. However, accurate measurement of pupil movement during convergence is necessary.

Accommodation ability of the subjects may have been sufficient because they were young and healthy. It is necessary to investigate it in a wide range of age groups.

5. Conclusion

After continuously performing the task for 2 hours using the game console, the near point significantly extended and subjective fatigue increased, showing that development of software reducing the burden on the accommodation function is necessary for viewing of action games. It is also necessary to take measures to prevent and reduce asthenopia for continuous viewing.

Acknowledgements

We are grateful to the students of the Orthoptist Course, Department of Sensory Science, Faculty of Health Science and Technology, Kawasaki University of Medical Welfare, for cooperation as the subjects of this study.

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