

The Effects of Astaxanthin on Accommodative Recovery

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Introduction

Supplements are becoming accepted as part of our daily diet and frequently seen shelved in stores. There are people who believe that supplements can be used to alleviate eye fatigue. As VDT (Visual Display Terminal) on electronic devices becomes smaller, the information displayed gets smaller too. Naturally, the user gets closer to the VDT, which causes stress to the eyes since it has to accommodate to the closeness of the screen (referred as accommodative fatigue).

Reports have shown¹⁾²⁾ that VDT usage, even for a short time, causes change in eye's ability to adjust to the smaller screen (referred as accommodation). Therefore, attention has been drawn to improve the eyes ability to accommodate.

In this study, we will report the effect astaxanthin (AX) have in aiding the eyes to recover from accommodative fatigue (referred as accommodative recovery) during rest after operating an electronic device (with VDT. Note: All electronic devices used in this study have VDT). AX used for this study is a constituent of a food additive product from Haematococcus alga coloring formula. We will report if AX have an effect on accommodative recovery and also report new knowledge acquired from this study.

I. Materials and Method

1. Tested Food Product

The tested food product, AX was in a capsule. It was made from Astarioil, a product derived from Haematococcus. Furthermore, one capsule contains 1 mg of AX. The product was made by Fuji Science Corporation.

2. Test Subjects

A total of ten people (5 men and 5 women) were used for the study. They were selected based on the following criteria:

1) Criteria for selection:

- (1) Between 30-42 years of age.
- (2) They can not be on medication and do not use supplements such as vitamins nor drink products containing taurine, a substance thought to aid recovery from fatigue in the eyes.
- (3) Gender was not considered a requirement.
- (4) Those who can follow and abide by the rules written in the consent form.

2) Subjects are excluded based on the following criteria:

- (1) People who are diabetics.
- (2) People who have past history of allergy to drugs.
- (3) Women who are pregnant, breastfeeding, or possibly pregnant.
- (4) Anyone the Principle Investigator (PI, who is a MD) believes is not conducive for the study. The PI explained the criteria to the subjects for a through understanding before the study and had them agree to the consent form explaining that the subjects are attending the study on a completely voluntary basis. The consent form explained the following:
 - ① The goal of the study, along with its methods and length of study.
 - ② Confidentiality of the subjects will be honored.
 - ③ Subjects will be allowed certain compensation in the case their health be compromised.
 - ④ Subjects are attending the study on a voluntary basis only and they are allowed to reject participation and leave the study when if they wish. Also, if that were to happen, they would not lose benefits from the study nor would they be treated with abuse (or subjective treatment?).
 - ⑤ Contact information in case health problems occur during the study.
 - ⑥ Rules the subjects have to follow.

3. Intaking of the Tested Food Product

All ten test subjects took six capsules of the tested food product (total of 6gm of AX per day) after dinner. This was repeated for a period of two weeks.

4. Examined Category and Exam Schedule

Chart 1 shows the fatigue the subjects felt in their eyes from operating electronics devices before taking the test food product (day 0) and after taking the test food product (day 14). Subjects also answered questionnaires.

1) Ophthalmologic Exam

The value obtained from the ophthalmologic exam consisted of: a). The Objective Diopter Value reading from the Nidex Autorefractometer (model: ARK720). b). The Accommodative Reaction Volume, which is the reading taken with the Nidex Autorefractometer along with use of the Fine Adjustment Analysis Device (model: AA-1). The value is the difference between the highest and the lowest refraction value when the adjustment load is between +0.5D to -3.0D. c). The average value of the High-Frequency Component in accommodative micro-fluctuation (HFC) when the refraction value is at its lowest and the adjustment load is between 0.00D and -0.75D.

Furthermore, the data was obtained by one person.

2) Questionnaire

The following questionnaires were given before and after operating the electronic device; and after rest following the use of it.

1. Questionnaire #1 (Before operating the electronic device)

1. I fatigue easily, 2. I fatigue somewhat, 3. I don't fatigue much, 4. I hardly fatigue, 5. I don't fatigue at all

2. Questionnaire #2 (After operating the electronic device)

1. I feel very fatigued, 2. I feel fatigued, 3. I feel a little fatigued, 4. I hardly feel fatigued, 5. I don't feel fatigued at all

3. Questionnaire #3 (After rest following the operation of electronic device)

1. I recovered a lot, 2. I recovered, 3. I recovered a little, 4. I do not feel much different, 5. I hardly feel any different, 6. I feel more fatigued

3) Operating Electronic Devices

The subjects operated the electronic device wearing corrective lens of -0.75D for 30 minutes. The electronic device the subjects operated was the Handyscreen Game Console (Nintendo Gameboy Corp.). To keep the game console constantly 30 cm from the eyes, a rope was tied to the console on one end and the other end around the subject's neck. The game they played was a simple, second-rated game .

5. Statistical Analysis

The values attained will be indicated as the average \pm standard deviation. Each value is analyzed using the paired t test. The statistical significance level is 5%.

II. Results

A total of nine subjects were examined. One developed allergic conjunctivitis and omitted from the study.

On questionnaire #1, one answered "I easily fatigue", six answered "I fatigue somewhat", and two answered "I hardly fatigue." The questionnaire was answered before uptake of AX and before operating the electronic device.

The subjects were distributed depending on the spherical refraction value of their eyes ranging from 0.00D~9.25D (chart 2). The average value of objective diopter before uptake of AX before, after, and after rest following operation IT equipment were $-3.30 \pm 3.33D$, $-3.06 \pm 3.43D$, $-3.31 \pm 3.33D$ respectively; the values after uptake of AX were $-3.39 \pm 3.44D$, $-3.17 \pm 3.61D$, $-3.53 \pm 3.61D$ respectively (figure 1). In comparison after operating electronic device to before operating electronic device before uptake of AX, one subject reported becoming nearsighted, two reported no change, and six reported becoming farsighted. After uptake of AX, none reported becoming myopic,

four reported no change, and five reported becoming farsighted. There was not many who became nearsighted after operating IT equipment (chart 3). In comparing after operation to after rest before uptake of AX, six reported becoming nearsighted, no one reported no change, and three reported becoming farsighted; after uptaking AX, six subject reported becoming myopic, two reported no change, and one reported becoming farsighted (chart 4). Many have become myopic after break.

The average value of HFC before uptake and after operations along with after rest were 52.09 ± 5.73 along with 55.79 ± 9.97 respectively. As indicated, the value increased after rest. After uptake, the values were 54.55 ± 5.05 along with 54.23 ± 4.73 respectively; the values did not change much (figure 2). The the amount of change in HPC after operation compared to after rest before uptake was $+3.70 \pm 6.56$, but after uptake was -0.32 ± 2.60 , indicating a decrease, which is an advantage ($P < 0.05$) (chart 5). The change in number of subjects who indicated a change in HFC value before uptake to after uptake, after operations and after rest, one reported an increase, none reported no change, and seven reported a decrease. Not many reported an increase in HFC value after uptake, after rest (chart 6).

The Accommodative Reaction Value before uptake, and after operations and after rest were $1.92 \pm 0.71D$ and $1.89 \pm 0.65D$ respectively; and after uptake were $1.80 \pm 0.48D$ and $1.93 \pm 0.46D$ respectively (figure 2). In comparison of HPC values before and after uptake, one reported an increase, one reported no change, and seven reported a decrease. Not a lot reported an increase of HPC value after uptake, after rest (chart 6).

In Questionnaire 2 before uptake and after operation, four answered “I feel very fatigued” or “I feel fatigued” and five answered “I feel a little fatigued”, “I hardly feel fatigued”, or “I don't feel fatigued at all.” In comparison to the same questionnaire after uptake of AX, two reported the former and seven reported the later (chart 8). Furthermore, on questionnaire 3, two answered “I recovered” after uptake, but none answered the same before uptake (chart 9).

	30 Minutes of Operation		20 Minutes of Rest	
	Operation of Electronic Device		Rest with Mask Over Eyes	
Objective Diopter Value	↑		↑	↑
Accommodative Reaction Value	↑		↑	↑
HFC Value	↑		↑	↑
Questionnaire 1				
Questionnaire 2			↑	
Questionnaire 3				↑

Chart 1: Examined Category and Exam Schedule

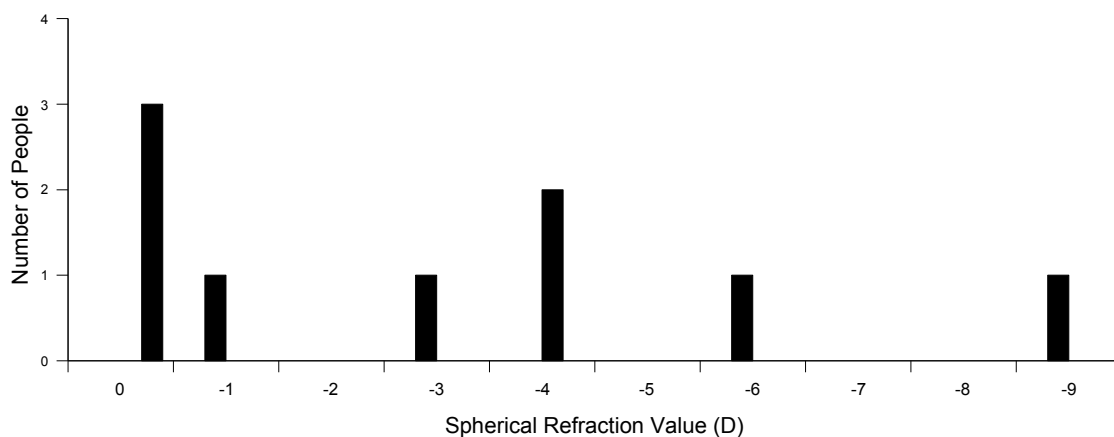


Chart 2: Distribution of Subjects by Spherical Refraction Value

Figure 1: Objective Diopter Value

Objective Diopter Value	Before Uptake of AX (Day 0)			After Uptake of AX (Day 14)		
	Before Operation	After Operation	After Rest	Before Operation	After Operation	After Rest
	-3.30±3.33D	-3.06 ± 3.43D	-3.31 ± 3.33D	-3.39 ± 3.44D	-3.17 ±3.61D	-3.53 ± 3.61D

Values are indicated as average ± standard deviation

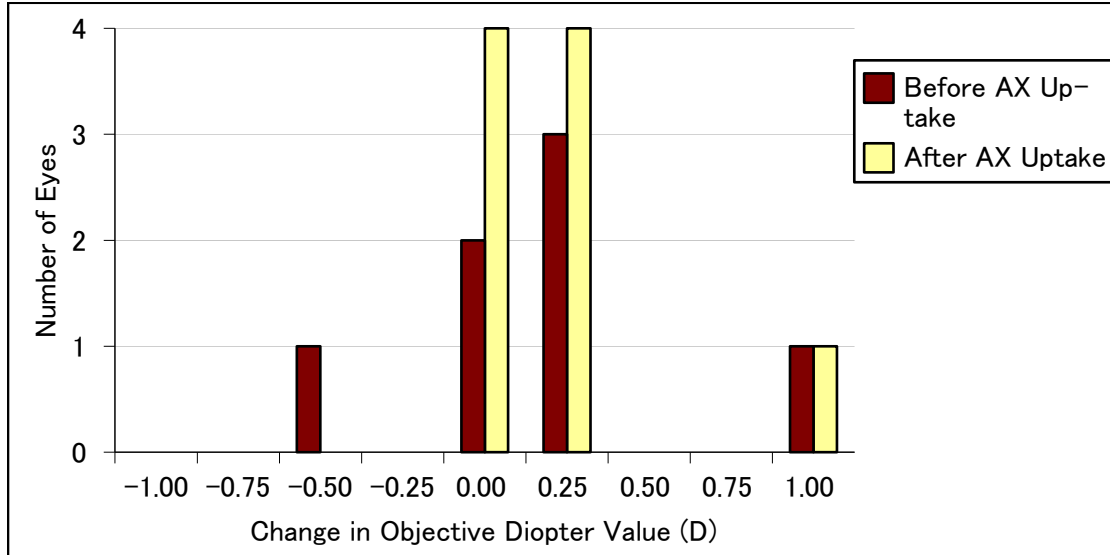


Chart 3: Change in Objective Diopter Value from Before Operation to After Operation.

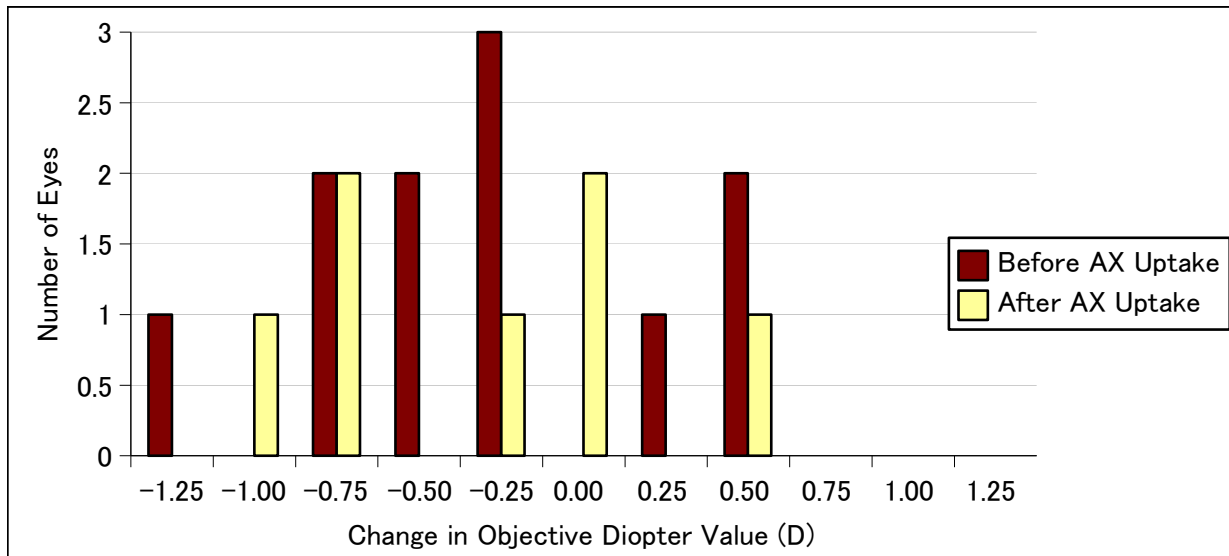
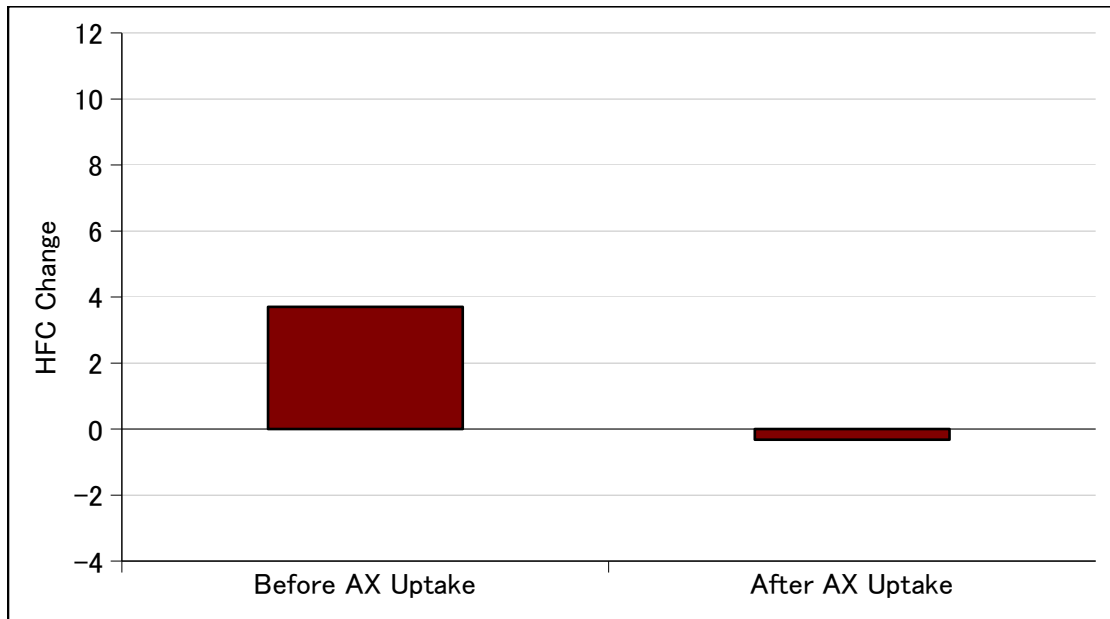


Chart 4: Change in Object Diopter Value from After Operation to After Rest



(Value show significant difference from before uptake to after uptake, $p < 0.05$)
 Chart 5: Difference in HFC value from After Operation to After Rest

Figure 2: HFC and Accommodative Reaction Value

	Before Uptake of AX (Day 0)		After Uptake of AX (Day 14)	
	After Operation	After Rest	After Operation	After Rest
HFC Value	52.09 ± 5.73	55.79 ± 9.97	54.55 ± 5.05	54.23 ± 4.73
Accommodative Reaction Value (D)	$1.92 \pm 0.71D$	$1.89 \pm 0.65D$	$1.80 \pm 0.48D$	$1.93 \pm 0.46D$

Values are indicated as average \pm standard deviation

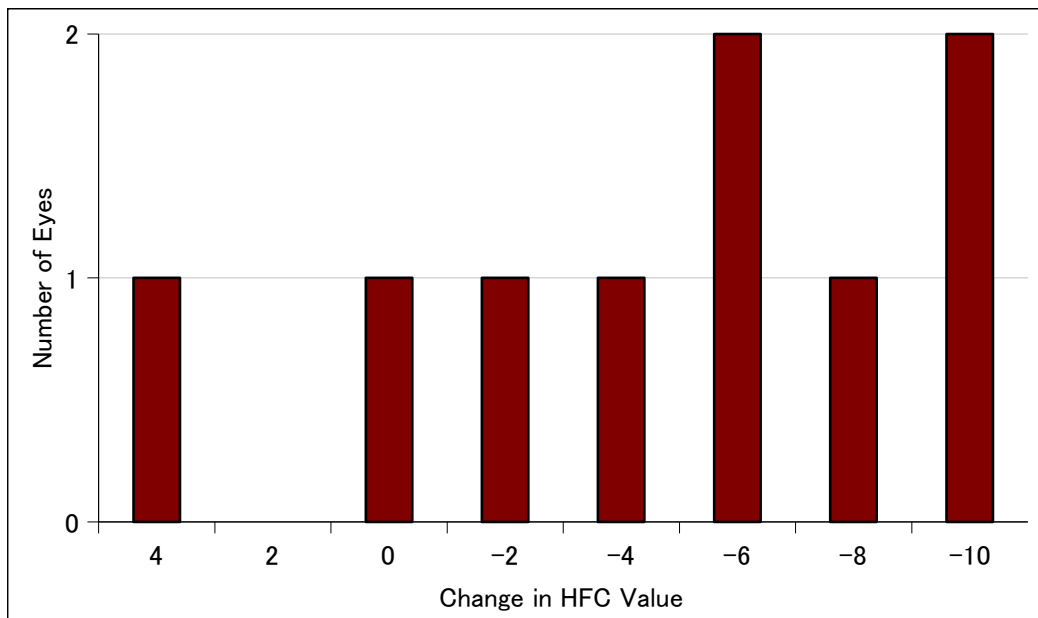


Chart 6: Change in HFC Value (when Accommodative Reaction is 0.00D~-0.75D)

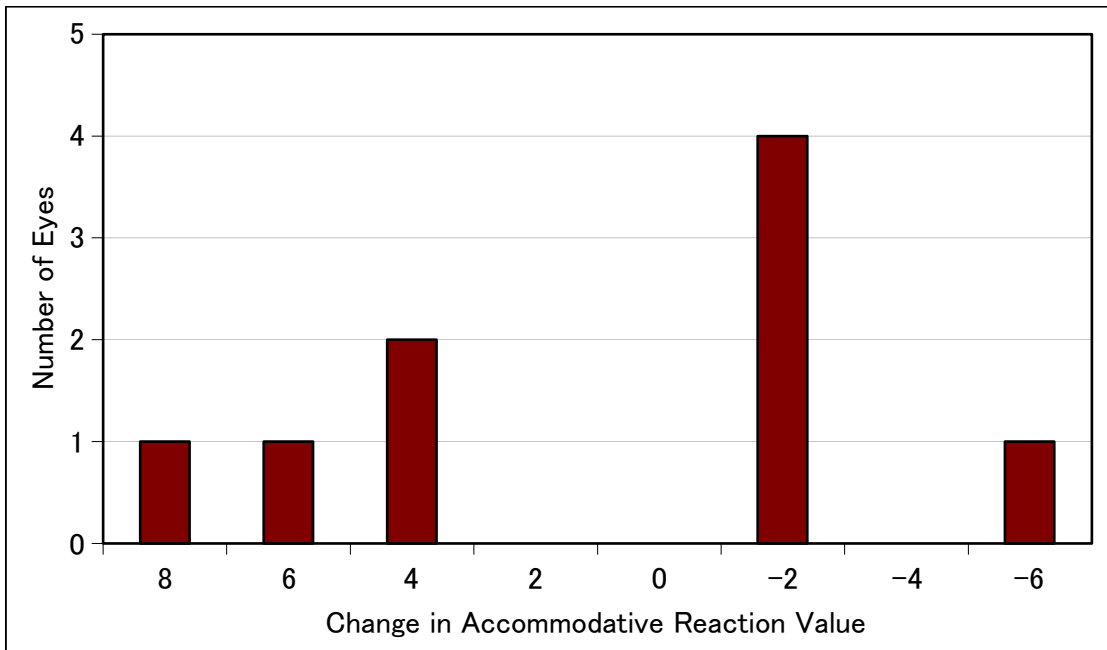


Chart 7: Change Accommodative Reaction Value (when it is between +0.50D~-3.00D)

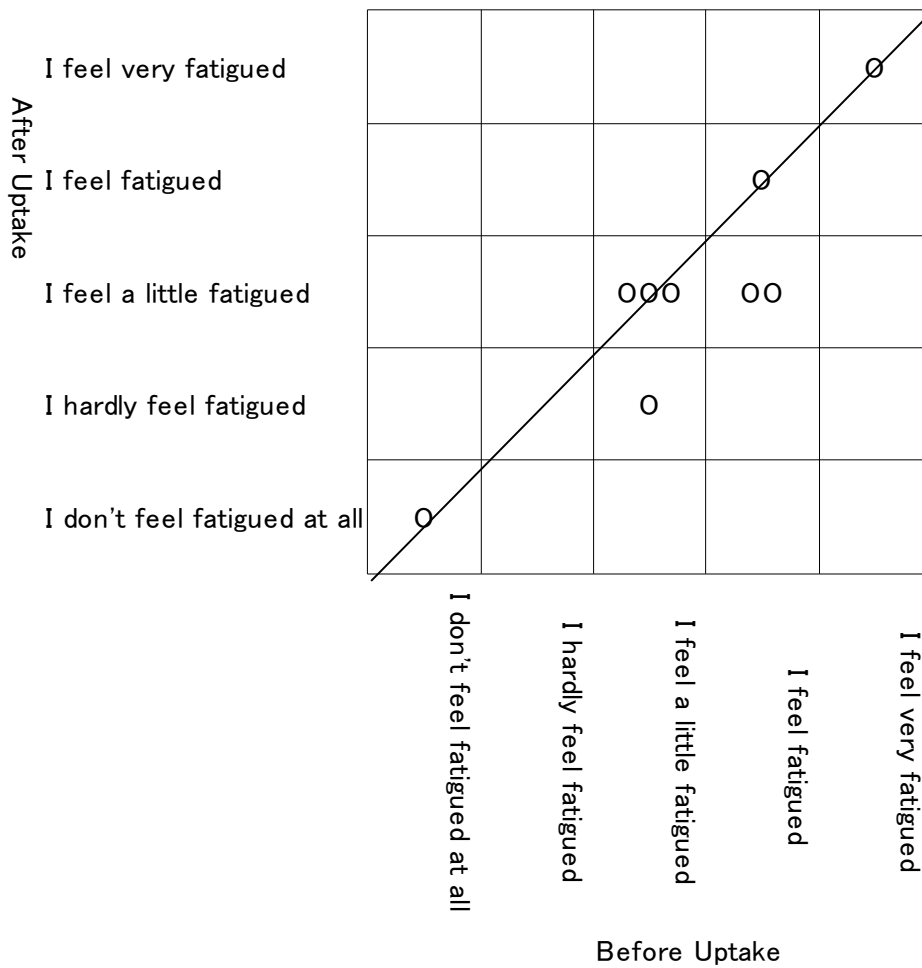


Chart 8: Questionnaire After Operation

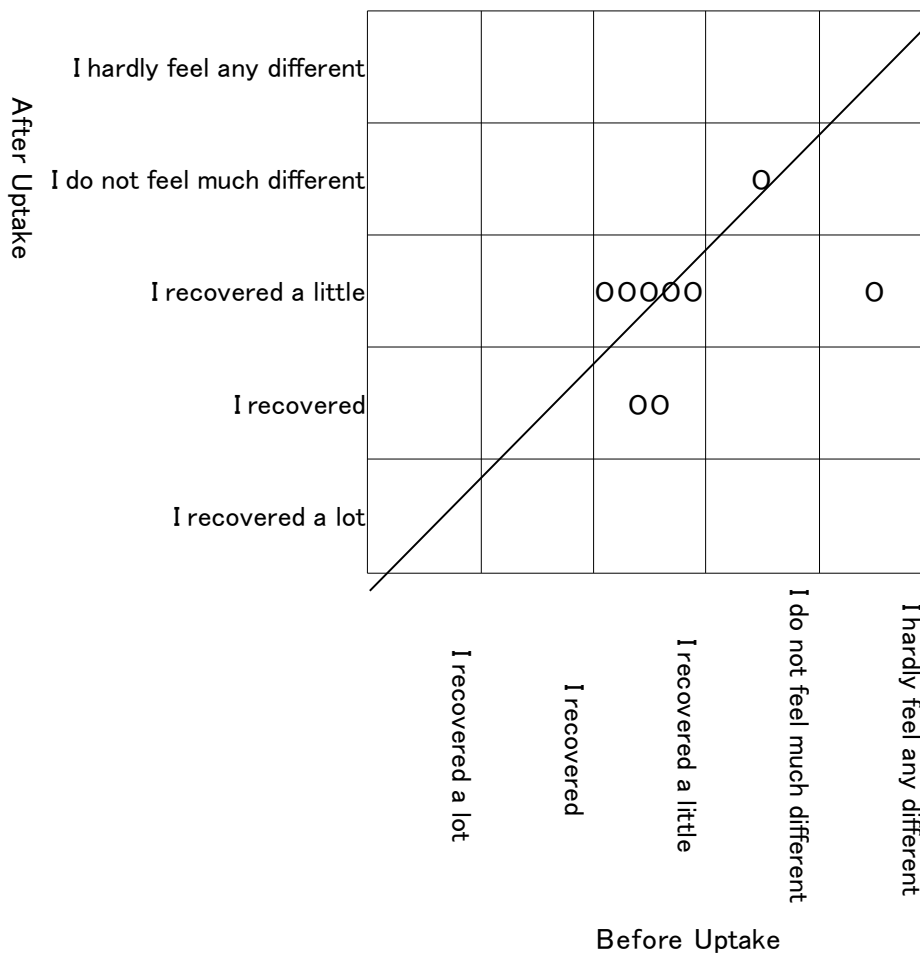


Chart 9: Questionnaire After Rest

III. Discussion

Micro-fluctuation frequency components can be classified into low frequency components of less than 0.6Hz and high frequency components of between 1.0 to 2.3 Hz. Previous studies indicated that low frequency components result from accommodative motion itself and high frequency components result from diopter fluctuations of the lens; hence, frequency components represent the activity of ciliary muscles. Accommodative load and accommodative micro-fluctuation are correlated, meaning an increase in HFC value indicates an increase of stress in the ciliary muscles. This study reported the effect of AX uptake on accommodative recovery by examining diopter value, HFC value and accommodative reaction amount. AX is a constituent of a food additive product from Haematococcus alga coloring formula.

We were able to find the effect AX has in accommodative recovery by inducing fatigue in the subject's eye by wearing excessively corrective glasses and operating electronic devices; and later comparing the effect rest has on the accommodative recovery before and after AX uptake.

The Objective Diopter readings measured by the Autorefect Meter, prior to operating electronic device, were $-3.30 \pm 3.33D$ before the uptake and $-3.39 \pm$ after the uptake, indicating no significant changes. The changes in objective diopter value after operation compared with before indicated hyperopic at $+0.25 \pm 0.41D$ before uptake and $+0.22 \pm 0.32D$ after uptake; however, the change was not significant. In addition, the change after operation and after rest indicated myopic at $-0.25 \pm 0.60D$ before uptake and $-0.36 \pm 0.47D$ after uptake. This means that before uptake, diopter values after rest returned to values of that before operation (The change after rest compared to before operation was $0.00 \pm 0.48D$.) After uptake, diopter values after rest indicated myopia compared to the value before operation. (The change in diopter values after rest compared to before operation was $-0.14 \pm 0.42D$.) The change indicated that AX worked on the activation of ciliary

muscles; however, the change was too small to indicate significant change.

In comparing changes in HFC value after operation to after rest before and after uptake, the values were $+3.70 \pm 6.56$ before uptake and -0.32 ± 2.60 after uptake respectively, indicating a significant decrease ($p < 0.05$) which supported the theory. Before AX uptake, ciliary muscles continued to tense after operation and no accommodative recovery was shown after 20 minutes of resting. However, after uptake, the readings suggested accommodative recovery after 20 minutes of resting.

Accommodative reaction amount before uptake was $1.92 \pm 0.71D$ after operation and $1.89 \pm 0.65D$ after rest, indicating a decrease after a rest ($-0.03 \pm 0.20D$). Moreover, the reaction amount after uptake was $1.80 \pm 0.48D$ after operation and $1.93 \pm 0.46D$ after rest. The change indicated an increase in accommodative reaction after rest compared to after operation; however, this increase ($+0.13 \pm 0.42D$) was not a positive in terms of supporting our idea.

In the questionnaires distributed after operation, four subjects reported fatigue before AX uptake, but only two reported fatigue after the uptake. Similarly, questionnaires distributed after rest reported no subjects who felt recovery before the intake, but two reported recovery after uptake. This result indicated that some subjects were consciously aware of the recovery.

This study suggests that AX has effect on accommodation and especially on removing accommodative fatigue, which aids in removing fatigue rapidly.

IV Conclusion

We have examined the effects of AX on accommodative recovery from rest after operation. Ten healthy volunteers participated in the study. One subject was removed from the study as that person developed allergic conjunctivitis during the study. Therefore, only nine volunteers were evaluated (9 dominant eyes) based the objective diopter value, the HFC value, and the accommodative reaction value. The result showed the HFC value after operation decreased significantly after AX intake compared to that of before uptake.

This study suggested that AX had effect on accommodation and worked on accommodative fatigue during the recovery process, which aided in relieving fatigue rapidly.