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EFFECTS OF TECNO AO ON OCULAR DYSFUNCTION DUE TO USE OF VISUAL DISPLAY UNITS

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Introduction

The symptoms of eye strain resulting from computer use are known as video display unit (VDU) syndrome. A report on the subjective symptoms of VDU syndrome and a wide range of ophthalmologic test results, such as the effects of VDU syndrome on the conjunctiva, the cornea, accommodation and convergence has been published in Japan (VDT Research Group of the Japanese Ophthalmologist Association, 1989). The cause of the harm done to the eyes in cases of this syndrome is considered to be the low frequency electromagnetic waves emitted by cathode ray tube (CRT) screens (Higuchi 1992; Horiuchi et al 1991; Tomioka et al 1996). A number of devices have been developed to prevent the damage to the eyes caused by the electromagnetic waves from these VDU screens, and have also been marketed, but none of them have been demonstrated scientifically to be effective. For the present study, we have taken the opportunity to use a magnetic oscillator, Tecno AO (TAO) antenna for VDUs, that has been found to offer protection to the living organism against the electromagnetic waves emitted from a VDU screen, by emitting a magnetic compensatory field (of extremely weak intensity in extremely low frequencies), thus inhibiting the VDU harmful effects. The mechanisms of this electromagnetic biological protection are studied by the quantum physics approach and the theory of oscillating property of saline and water solutions (V. Binhi -PIERS 1999)

The objective of this study was to assess the degree of harm to the eyes from VDU exposure in a group using VDU screens and to compare it with an other group also using VDU screens, but the screens being equipped with the Tecno AO device.

Materials and Methods

The subjects participating in this study were ten healthy women laboratory technicians from Kitasato University Hospital, who were between 20 and 30 years of age. All were either emmetropic or had mild myopia of less than –2 D. None of them wore contact lenses or performed VDU work as an occupation. In order to avoid affecting their daily work duties, Sundays and other holidays were selected for conducting their tests. All of the subjects performed the identical VDU tasks, either with a TAO fitted, or without. Also, to avoid the effects of the previous loading tests , an interval of at least one week was interposed between one VDU task test and the next. A TV game was chosen as the VDU task so as to keep the subjects' interest and to make possible prolonged periods of uninterrupted VDU use. The duration of each task was 4 hours continuously.

The television sets employed in this study were 14-inch model TH-14RF1 Panasonic TVs, and the game units were Sega Saturn HST3220s. The electric and magnetic fields were measured in a region corresponding with the head position of the subjects during performance of the task, that is at a distance of 1.2 m from the screen. Using the magnetic field meters MFM1000 and MFM10 (Combinova Inc.), the magnetic fields measured between 1 KHz and 400 KHz were 17.2nT, and those determined with a Genitron model were 58 nT ; while the electric fields were 9 V/m. The TAO units attached to the top and front of the frame of the TV screens did not modify these electric and magnetic values.

The precise function of these TAO devices was not explained to the participants before the experiment. Some VDUs were fitted with TAOs and the other were not so, without any comment given to the participants.

The first measurements session was : one set of tests before starting to play video game and another set of tests immediately after 4 hours of video game for the group A =without TAO; and after 4 hours of video game with TAO on the TV for the group B. The second measurements session was after one week of respite : one set of measurements before to start playing with TV game and another set of tests immediately after 4 hours of video game without protection for group A and with TAO for group B.

The following ophthalmological tests were performed:

1. **Corneal epithelium examination with fluorescein staining.**

The degree of corneal epitheliopathy was evaluated using a slit-lamp biomicroscope with fluorescein staining, and expressed numerically as a score from 0 to 4 as previously described (Namba T et al.) (Figure 1)

2. **Visual acuity and refraction tests**

These tests comprised objective measurement of refractivity with an autorefractometer, and a corrected visual acuity test for subjective measurement of refractivity.

3. Near point of accommodation

The repeat analysis method was carried out (10 measurements) for the near point, using an Ishihara accommodometer.

4. Tests of responses to step stimulation of accommodation

As a step stimulus, a 3 diopter accommodation load was applied, and the accommodative response and the pupillary response (near response) to that stimulus were determined with an autorefractometer specially modified to produce step stimuli. The actual record of the accommodative response (Figure 2) and its variables (Figure 3) are presented herein; but, to avoid the complexity of all the variables in the Figure, only those for the length of time taken for the tonic response to be completed (tonic response time) are shown. An analysis of similar variables was made for relaxation. The items selected for evaluation were the refractivity before and after the accommodation step stimulus test, the amplitude of accommodation, the tonic response time, the relaxation time, and the speed of accommodation, and for each of these, the difference in the values before and after the VDU task was carried out was found, and the mean value of 10 successive measurements was calculated. Also, because of the burden imposed by these tests, only the right eye of each subject was tested.

5. Pupillary response to accommodation step stimulus (near response)

The pupillary response at the time of the accommodation step response was recorded. The raw data are shown in Figure 2 together with the accommodative response. Measurements were repeated 10 times each, and the mean values were calculated. The object of the analysis was to obtain the difference between the diameters of the pupil before and after accommodation loading, that is, the amount of pupillary contraction.

6. Smooth pursuit eye movement test

Electrooculograms were recorded before and after the VDU task.

Results

1. Corneal epithelial injury

Corneal epitheliopathy scores after completion of the task without the use of a TAO, determined by means of fluorescein staining, were 1.40±0.96, but with a TAO, were 0.70±0.73, showing a significant difference of p=0.016 (Table 1).

2. Visual acuity and refractivity

No difference dependent on whether a TAO was fitted or not was seen in visual acuity or the far point.

3. Near point of accommodation

The use of an Ishihara accommodometer to make 10 repeated measurements yielded the results shown in Table 2. With a TAO in place, the increase of the distance to the near point was significantly greater (p=0.041) than when no TAO was used. The far point was calculated by refraction, but no difference was seen.

4. Accommodation step response tests

The differences between the results for accommodation step response before and after the assigned task are shown in Table 3.

In the speed of the tonic response, no difference was observed, but in the speed of relaxation, a difference between the before-task and after-task values was found: without a TAO, the tonic response time (to the return of accommodation) had become shorter (0.827±1.11) without any TAO, whereas, with the TAO, a value of –0.69±1.05, indicating that return of accommodation was slower, was obtained. A test of the significance of the difference showed a significant p value of 0.006. In the degree of accommodation, time, amplitude of accommodation, and T1 and T2, no significant differences were seen.

5. Pupillary near response

The pupils are very susceptible to change, and, since the values obtained in the present study with the measuring devices exhibited a large degree of scatter, it was difficult to provide accurate numerical values. For that reason, the values for the pupillary near response were judged by eye from the raw data, and the results are presented in Table 4. The "No change" column in the Table contains the numbers of cases in which the pupillary diameter and near response after the VDU task are not different from those before; and "Abnormal near response" indicates weakening or instability of the near response after the task, compared with before; "Mydriasis" shows in how many cases of dilatation of the pupil in a relaxed state were seen after the task in comparison with before; and "Miosis" lists the number of cases showing contraction of the pupil in a relaxed state after the task in comparison with before. When the TAO was not used, the degree of the near response was abnormal in 6 eyes, there was no change in 2, dilatation of the pupil in 4, and pupillary contraction in 1; whereas, with the use of the TAO, abnormal near responses were seen in 2 eyes, no change in 6, pupillary dilatation in 2, and pupillary contraction in none. Thus, when no TAO was fitted, the number of eyes recorded was 13, but this was because some eyes showed more than one abnormality.

6. Smooth pursuit eye movement

No abnormality of smooth pursuit eye movement in either the TAO or the non-TAO group.

Discussion

It was possible to determine the extremely weak magnetic oscillation emitted by the TAO by means of a SQUID (Superconducting Quantum Interference Device or Biomagnetometer), which is usually used for monitoring the magnetic field of the brain. When the magnetic field emitted by the TAO was analyzed with the SQUID, the frequencies range was between 6 Hz and 27 Hz. with two main peaks : the strongest one at 12Hz and the other one at around 24Hz. The frequencies induction was between 100 and 300 femtoTesla, with the main 12Hz peak at 300femtoTesla. Although the TAO emitted field was extremely weak, however, the biological effects of these magnetic signals, at a quantum level, are great enough to prevent cell damage, and it has been demonstrated that the emission of the TAO device is of sufficient strength to prevent harm to tissues (Binhi et al, 1998). Already, improvements in the brainwaves of VDU workers by the compensatory magnetic oscillation emitted by TAOs have been reported (Catier, 1996). The present experiments were performed to study the usefulness of TAO in relation to the visual systems of VDU workers.

The presence of epithelial injury on the corneas of VDU workers is already well known (Atumi and Suzumura, 1982). Regarding the mechanism of its occurrence, reports have pointed out decreases in lacrimation (Iwasaki 1987) and in the frequency of blinking (Iwasaki and Kurimoto 1985). However, this was not the result of staring fixedly at the television screen; but since corneal epithelial injury was observed also in experiments in which mice, which do not ordinarily blink at all, were exposed to a television screen (Higuchi 1992), it is difficult to avoid the conclusion that the radiation emitted from the screen has a role in this kind of injury. CRT screens manufactured in Japan emit electromagnetic waves that do not cause such injury, which is due to frequencies of 1 MHz or less. (Higuchi 1992, Horiuchi and Namba 1991, Tominaga 1993). As a result of the work carried out in the present study, using television screens without TAO devices, a marked difference was seen in the occurrence of epitheliopathies when a TAO was fitted, although the nature and duration of the task were identical. These findings not only demonstrate the usefulness of the TAO device in reducing epitheliopathy, but also suggest that low-frequency electromagnetic waves that emerge from CRT screens are a major factor in the development of such injury. Of course, the fact that epithelial injury is easy to detect on the lower half of the cornea has been reported previously, but also, the contribution of the layer of lacrimal fluid on the cornea cannot be denied.

It has been reported that impairment of accommodation can be induced by VDU use (Japanese Ophthalmologist Association 1994), and also that myopia can result from it (VDT Research Team of the Japanese Ophthalmology Society 1987, Araki 1988, VDT Research Team of the Japanese Ophthalmology Society 1988). In addition, the development of myopia is reportedly more severe, the younger the subject is (Araki 1988), and one report states that CRT work also shortens the distance to the near point (Namba and Tomioka 1998). Thus, the tonic accommodative response is increased. In the present study, there was no tendency in the non-TAO group for the near point distance to be reduced, in other words, no tendency toward an increase in the amplitude of accommodation. This may have been because the CRT screens were smaller than those used in past studies, so that the effect of electromagnetic waves was weaker. In the TAO group, on the other hand, a weakening of accommodation was observed—that is, a tendency was seen for accommodation to weaken in the same way as in the case of screen-based tasks in a TV projector device with extremely little electromagnetic wave emission (Namba and Tomioka 1998). It was thought, not that an abnormal degree of tension had developed, but that a totally expectable stress phenomenon appeared as a

result of the task load. That is, the use of a TAO was considered to be effective in preventing abnormal accommodative tension that was probably attributable to the electromagnetic waves from the CRT. Also, when a TAO device was in place, the speed of relaxation of accommodation due to the step response became slower, and could be said to have manifested eye strain in a similar manner, but it is difficult to give an explanation in such clear terms.

Furthermore, the near response of the pupils became worse in 6 subjects when no TAO was used, while only 2 subjects showed a worse response when a TAO was in place. The diameter of the pupil without the imposition of an accommodation load and without a TAO was mydriatic in 4 cases and miotic in 1, but with the TAO, there were only 2 cases of mydriasis and none of miosis. The pupil is a site where the operation of the autonomic nervous system may be observed directly, but both mydriasis and miosis can be thought of as abnormal reactions, and it was considered that such reactions had been shown to be prevented by the TAO.

There has been wide-ranging discussion on the ill-effects of low-frequency electromagnetic waves on health, and already, a huge number of reports have dealt with calcium abnormalities at the cellular level caused by these waves (Tomioka 1996, Lerchl et al 1991, Carson et al 1990, Walleczek 1992). Calcium metabolism may also play a part in functional impairment of the eyes due to VDU use, but the present study has clearly demonstrated the usefulness of the Tecno AO device.

Summary:

When the eye damage in healthy adults performing identical tasks for four hours using television screens either fitted with or without a Tecno AO device (TAO) was examined comparatively, the following results were obtained.

1. There was significantly less corneal epitheliopathy in the subjects using a TAO than in those without.
2. Increase of the distance to the near point was seen with the TAO, and when this was considered in conjunction with the relevant literature, it was considered that TAO prevented the occurrence of abnormal tonus of accommodation.
3. When TAO was fitted, a slowing of the speed of relaxation of accommodation was observed in the step response.
4. There were fewer abnormalities of the pupils in near vision when the TAO was used than without it.

These results suggested that TAO is useful for protection of the eyes when work on VDUs is carried out.

Acknowledgments

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Figure 1. Scoring of injuries to corneal epithelium (fluorescein staining).

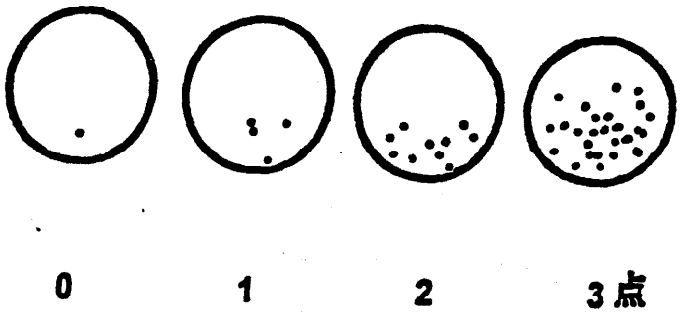

Figure 2. Accommodative reflex and near reaction of the pupil in the step response. The rectangular step in the solid line at the bottom represents the 3 D step stimulus, the lower level representing 10 recordings for accommodation and their mean value curve, and the upper level, the mean value curve of 10 recordings of pupillary movement. The left ordinate indicates diopters of accommodation, and the right ordinate, the pupil area. The abscissa represents time. D1 is the refractivity at rest, before accommodation loading; D2, the refractivity after 3 diopter loading; WIDTH, the difference between D1 and D2, that is the amplitude of accommodation; GRAD, the accommodation gradient; T1, the time from the start of loading to the start of accommodation; T2, the time from the start of loading to the end of accommodation; S1, the pupil area at rest; and S2, the pupil area after the near reaction.

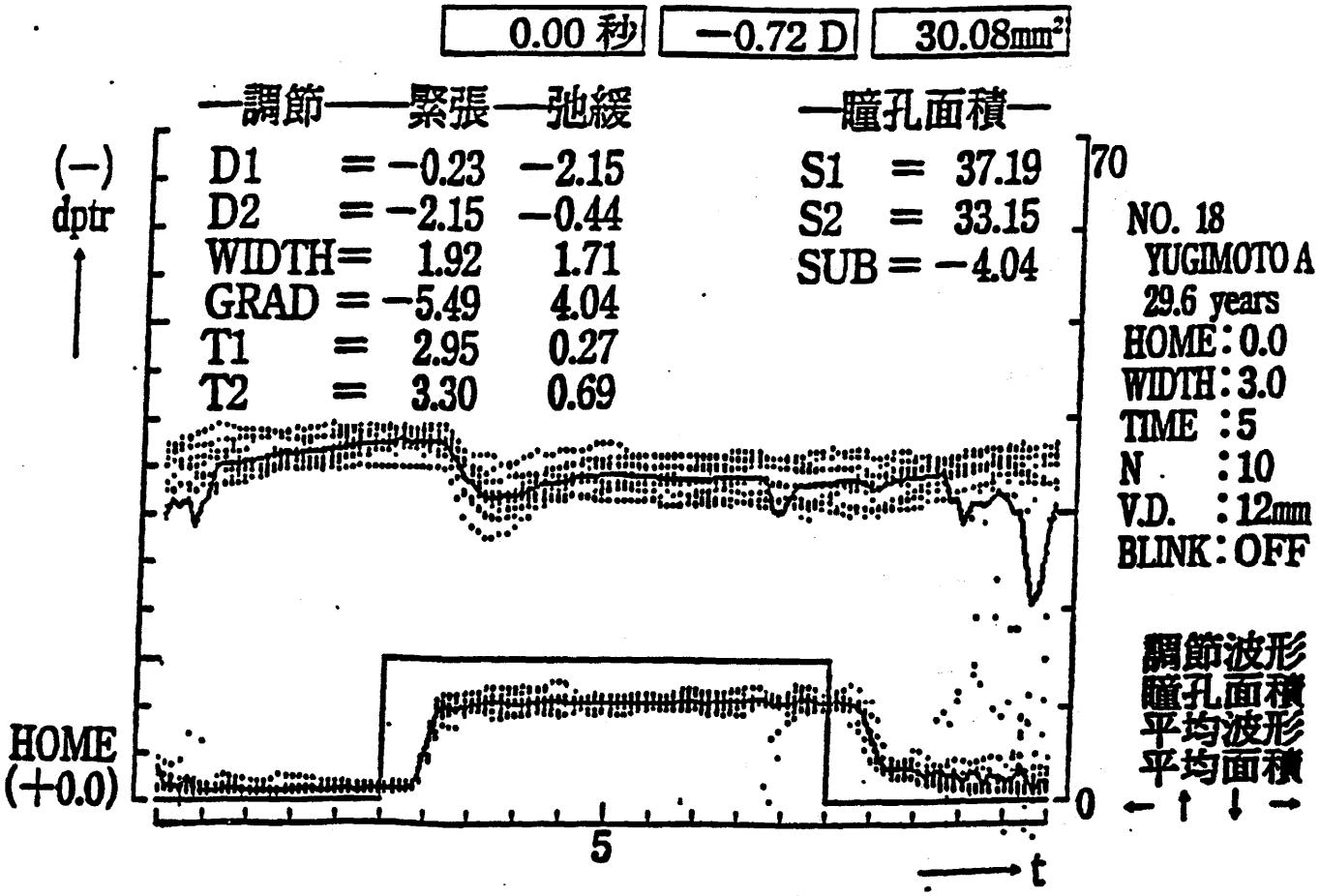

Figure 3. Parameters of accommodation in the step response. To avoid unnecessary complication, only the parameters of the tension phase are shown. Similar measurements were made in the relaxation phase also, but the D2 of the tension phase was used as the baseline of the relaxation phase.

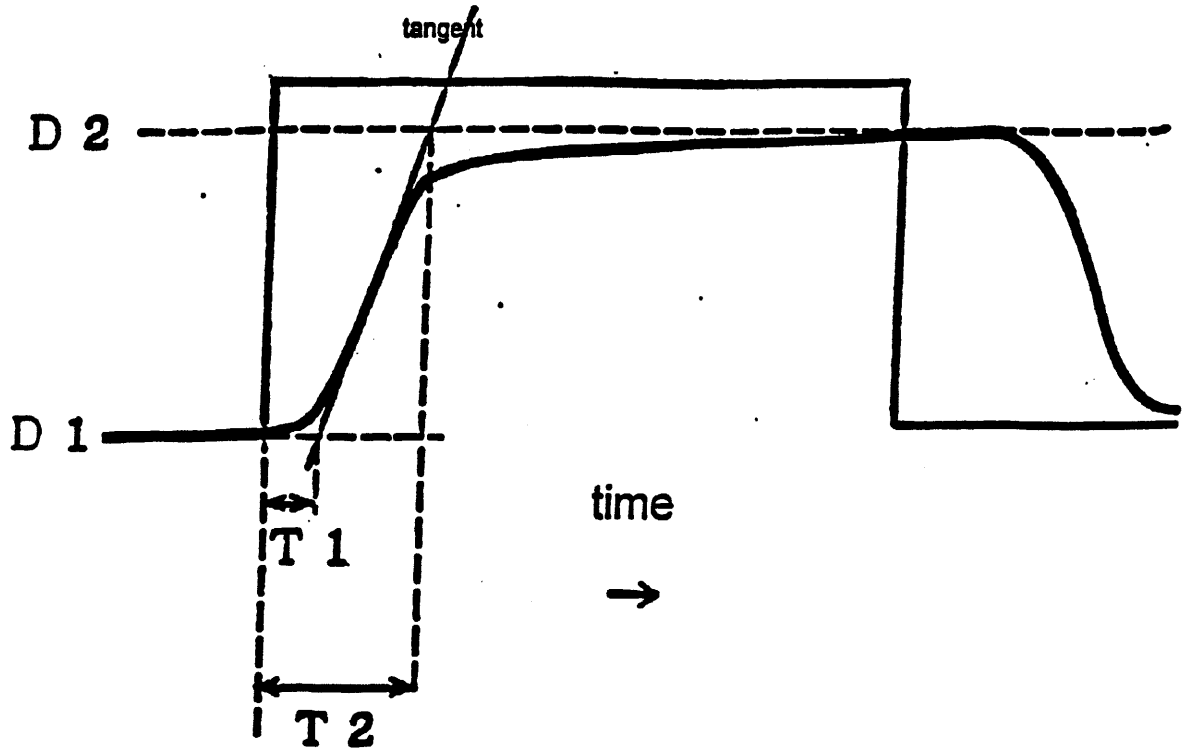

Table 1. Corneal epitheliopathy scores with and without Tecno AO

	Without TAO	With TAO	p value
Corneal epitheliopathy score	1.40±0.96	0.70±0.73	0.016

Table 2. Accommodation near and far points with and without Tecno AO

	Without TAO	With TAO	p value
Increase of near point distance	0.08±1.17	1.98±1.50*	0.041
Increase of far point distance	–0.02±0.22	-0.09±0.17	0.300

Key: D1, refractivity at rest, before accommodation loading

D2, refractivity

*p<0.05

Table 3. Accommodation near and far points with and without Tecno AO

	Without TAO	With TAO	p value
D1 (tonic)	0.04±0.16	–0.02±0.13	0.37
D2 (tonic)	–0.20±0.40	-0.06±0.21	0.34
D1 - D2 (tonic accommodation amplitude)	0.24±0.37	0.04±0.18	0.16
D1 (relaxed)	-0.09±0.24	-0.06±0.21	0.77
D2 (relaxed)	–0.08±0.27	0.01±0.13	0.34
D1 - D2 (relaxed accommodation amplitude)	0.11±0.37	0.07±0.19	0.79
T1 (relaxed)	0.19±0.42	-0.21±0.63	0.10
T2 (relaxed)	3.07±3.66	3.05±3.37	0.008
Speed of tonic response	0.32±1.15	0.33±1.42	0.99
Speed of relaxation	–0.827±1.11	-0.69±1.05**	0.006

Key: D1 refractivity at rest, before accommodation loading
D2 refractivity after 3 diopter loading
T1 time from start of loading to start of accommodation
T2 time from start of loading to end of accommodation
**p<0.001

Table 4. Changes in pupil diameter during accommodation step response

	No change	Aggravation	Mydriasis at rest	Miosis at rest
Without TAO	2	6	4	1
With TAO	6	2	2	0

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VDT 作業負荷による眼機能とテクノ AO の効果

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Ocular functions durinq loadinq by visual display terminal and the effect of Tecno AO

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I 緒 言

コンピューター画面作業時の疲労現象に対しては visual display termainal（VDT と略）症候群と呼ばれている。この VDT 症候群に関しては日本眼科医会が早くから VDT 研究班を作り，報告書を提出している[1]。その中では，VDT 症候群の自覚症状や，その眼に関する訴えが多い理由，結膜・角膜への影響，調節，輻輳など広範な眼科的な検査結果が詳述されている。この VDT 症候群の眼障害性の発症に cathod ray tube（CRT と略）画面から発生する低周波電磁波の影響が問題視されてきている[2)~4)]。一方その VDT 画面からの電磁波障害を防御する各種の機器が開発，販売されているが，その有効性について科学的証明を得ているものはほとんどないと言ってよい。

今回 VDT 画面からの電磁波を受けて，変調した微弱電磁波を発生して生体防御作用を示すとされるアンテナ，テクノ AO（以下 AO と略）を使用する機会を得た。そして AO 無装着および，AO 装着 VDT 画面により同一作業負荷を被験者に掛けてその眼への影響を観察した。

II 方 法

被験者には20歳から30歳までの健康な北里大学病院女性検査技師10名の同意を得て選んだ。これらの被験者は両眼とも正視または－2D 以下の軽度近視のものとした。コンタクト装用者は入っていない。また VDT 作業を専門とする職種の人間は入っていない。また日常勤務の影響を避けるために，検査日には日曜を選んだ。必ず同一被験者に AO 装着，および AO 無装着の下での同一作業負荷試験を行なった。また前回の負荷試験の影響を避けるために，作業負荷試験には最低 1 週間以上の間隔を置いた。作業負荷は被験者の興味をつなぎ，長時間継続作業が可能とするために，TV ゲームとした。使用 14インチ TV はパナソニック TH-14RF1 を使用した。ゲーム機はセガサターン HST3220 を使用した。作業負荷時間は連続 4 時間とした。なお作業時頭部の位置に相当する部，すなわち画面より1.2 m での磁場および電場を測定した。Magnetic field meter MFM1000 および MFM10（Combinoba 社製）で測定した 1 KHz から400 KHz での磁場は17.2 nT，また Genitron で測定した磁場は58 nT であり，電場は 9 V/m であった。AO は TV 画面前面上方の枠に張り付けた。なおこの AO の機能の詳細については被験者には事前には知らせていない。

眼科的検査項目は以下の通りである。

1） 角膜上皮検査（フルオレスセイン染色による）

角膜上皮症の程度は，細隙燈顕微鏡観察下でのフルオレスセイン染色による程度を既報と同様に 0~4 点までの評価として数値化した（図 1）[5)]。

2） 視力，屈折検査

他覚的検査（自動屈折計による屈折度）

自覚的検査（矯正視力検査による屈折度）

3） 調節近点

石原式近点距離計で10回反復測定した。

4） 調節のステップ応答検査

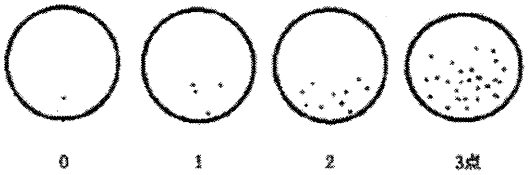

図 1 角膜上皮症のフルオレスセイン染色によるスコア模式図

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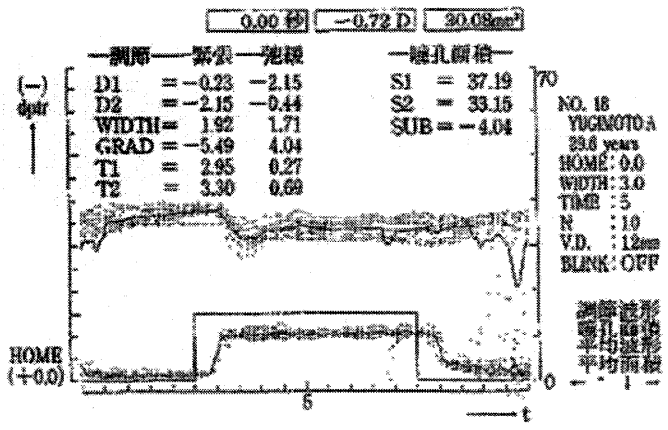

図2　ステップ応答の調節反応と瞳孔の近見反応の記録

矩形の線は3Dのステップ刺激，下段は調節の10回記録とその平均値曲線．上段は瞳孔の動きの10の記録と平均曲線。左縦軸は調節のD，右縦軸は瞳孔面積。

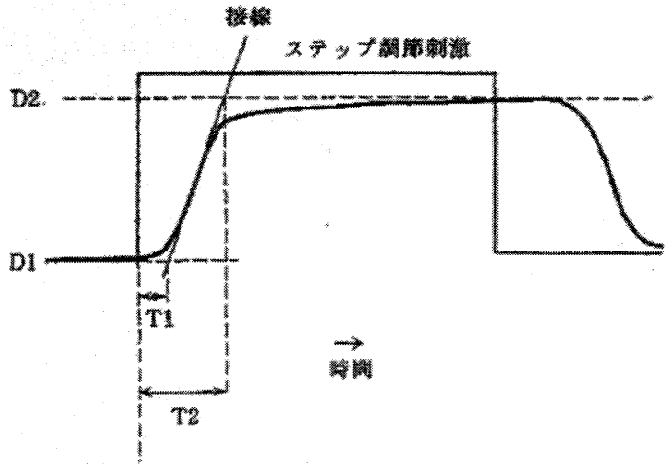

図3　ステップ応答の調節のパラメーター

煩雑さを避けるために調節の緊張相のパラメーターのみを記した。弛緩相においても同様に計測したが，緊張相のD2がそのまま弛緩相の基線となる。

実際のステップ応答の記録（図2）と，そのパラメーター（図3）を示す。なお図中のパラメーターは煩雑さを避けるために，緊張時のパラメーターのみを記入してある。弛緩時にも同様なパラメーターを解析した。ステップ刺激は3Dである。評価の対象としたのは，調節のステップ刺激前後の屈折度，調節幅，緊張時間因子，弛緩時間因子，調節速度とし，各値とともに，作業負荷前後の差を解析対象とした。なお10回連続測定の平均値で表した。なおこれらの検査は被験者に負担が非常に掛かるために，右眼のみの検査とした。

5）　瞳孔の近見反応

調節のステップ応答時の瞳孔の反応を記録した。実際の測定結果を図2に調節反応と合わせて示す。測定回数は10回として，その平均値をとった。解析対象は調節負荷前の瞳孔径と調節負荷後の瞳孔径の差，すなわち縮瞳幅である。

6）　眼球の活動性追従運動検査

作業負荷前後での眼電位図を記録比較した。

Ⅲ　結　　果

1）　角膜上皮障害

フルオレスセイン染色による角膜上皮障害のスコアはAO無装着では負荷後で1.40±0.96，そしてAO装着では0.70±0.73で，p0.016と明らかに有意であった（表1）。

2）　視力，屈折検査

視力，遠点ともAO装着の有無による差は認められなかった。

3）　調節近点検査

石原式近点距離計で10回反復測定した結果は表2の通りであり，AO装着では近点の延長がp0.041で有意に認められた。また屈折より遠点を計算したが，差は認められなかった。

4）　調節のステップ応答検査

各パラメーターの作業負荷前後の差を表3に示す。

緊張性の速度では差が認められなかったが，弛緩性の速度の作業負荷前後の差をとると，AO無装着で0.827±1.11と調節の戻りが早くなっており，一方AO

表1　AO無装着，および装着での角膜上皮症のスコアー

	AO無装着	AO装着
角膜上皮症スコアー	1.40±0.96	0.70±0.73*

表2　AO無装着，および装着での調節近点および調節遠点の延長

	AO無装着	AO装着	p
近点の延長	0.08±1.17	0.98±1.50*	0.041
遠点の延長	−0.02±0.22	−0.09±0.17	0.300

表3　AO無装置，および装置での各パラメーター作業負荷前後の差の値と比較

	AO無装着	AO装着	p
D1（緊張）	0.04 ±0.16	−0.02±0.13	0.37
D2（緊張）	−0.20 ±0.40	−0.06±0.21	0.34
D1−D2（緊張調節幅）	0.24 ±0.37	0.04±0.18	0.16
D1（弛緩）	−0.09 ±0.24	−0.06±0.21	0.77
D2（弛緩）	−0.08 ±0.27	0.01±0.13	0.34
D1−D2（弛緩調節幅）	0.11 ±0.37	0.07±0.19	0.79
T1（弛緩）	0.19 ±0.42	−0.21±0.63	0.10
T2（弛緩）	3.07 ±3.66	3.05±3.37	0.008
緊張速度	0.32 ±1.15	0.33±1.42	0.99
弛緩速度	0.827±1.11	−0.69±1.05**	0.006

表4 作業負荷後の瞳孔の変化

	変化なし	近見反応異常	散瞳	縮瞳
AO無装置	2	6	4	1
AO装着	6	2	2	0

装着では−0.69±1.05と戻りが遅くなっている。有意差検定ではp0.006で有意差が認められた。緊張および弛緩時の調節度，時間，調節の幅，T1およびT2では差が認められなかった。

5) 瞳孔の近見反応

瞳孔は非常に変動しやすく，今回の計測機器の打ち出す数値にばらつきが多いために正確に数値化するのは困難であった。そのために，瞳孔反応の実際の記録から反応を判断して表4に示した。表中の「変化なし」は作業負荷後に瞳孔径および近見反応が負荷前に比べて変化していないもの，「近見反応異常」は作業負荷後に瞳孔の近見反応の減弱や不安定性を示したもの，「散瞳」は作業負荷後の安静時に作業負荷前より散瞳をしめしたもの，「縮瞳」は作業負荷後の安静時に作業負荷前より縮瞳を示したものである。AO無装着では作業負荷後に反応量の近見反応異常が6眼，変化なしが2眼，散瞳4眼，縮瞳1眼であったのに対し，AO装着では近見反応異常2眼，変化なしが6眼，散瞳が2眼であった。なおAO無装着眼では総計が13眼となっているが，これは重複した異常を示す例があったためである。

6) 眼球の滑動性追従運動

AO無装着，AO装着群ともに異常は認められなかった。

N 考 按

AOの発生する超微弱磁気は脳の磁界測定に使用されるSQUID（超伝導量子干渉計）によって測定が可能である。TV画面による曝露直後にAOより発生している電磁波を測定すると，10 Hz前後および，27 Hz前後に集中した発信が認められる。そしてその強度は100〜300 femoTesla．そして−280 brui de fondから40 brui de fond程度の動きを示すという極めて弱い発信である。しかし電磁波の生物学的な作用は量子レベルで十分であり，AOの発信は充分の強度であることが示されている[6]。そして，これまでにはAOから発する補償電磁波がVDT作業者の脳波を改善することが報告されている[7]。今回の実験はAOのVDT作業への視覚系への有用性を検討する目的で行われた。

VDT作業者の角膜上皮症はすでによく知られている[8]。この発症機序として，涙液産生の減少[9]や瞬目回数の減少[10]を指摘する報告もある。しかし，TV画面を凝視するわけでもなく，もともと瞬目運動も示さないマウスのTV曝露実験でも角膜上皮症が認められている事実[3]はCRT画面から放射される電磁波の関与を考慮せざるを得ない。日本製のCRT画面からは1 MHz以下の通信障害にならない電磁波が放射されている[2][11]。今回のAO無装着のTV画面での作業では，AO装着作業での同一作業負荷による角膜上皮症の発症は明らかな差が認められた。このことはAOの角膜上皮症に対する有効性を示すとともに，CRT画面から発生する低周波電磁波の影響が角膜上皮症発症の大きな因子であることを示唆している。もちろん角膜上皮症が角膜下方に認められやすい点はこれまでの報告と同じであり，角膜の涙液層の関与を否定するものではない。

VDT作業によって調節機能に障害が起きることも報告されている[12]。長期の経過観察で近視化も報告されている[13]〜[15]。そして，近視化は若年者ほど強いと報告されている[14]。過去の報告ではCRT作業で近点の短縮が報告されている[5]。すなわち調節の緊張の亢進である。今回ではその短縮傾向，すなわち調節幅の増強がAO無装着では認められなかった。これはCRT画面が過去の報告よりも小さく，漏洩電磁波も弱かったためかもしれない。一方AO装着では，調節の減弱が認められている。すなわち電磁波負荷の極めて少ない投影式のスクリン画面作業負荷と同様に調節の減弱傾向が認められた[5]。これは作業負荷により，異常な緊張が生じるのではなく，当然現れるべき疲労現象が生じていると考えられた。すなわちAO装着はCRTからの電磁波によると思われる異常な調節緊張を防ぐ効果があるものと思われた。またAO装着ではステップ応答による調節の弛緩の速度が緩やかになり，疲労現象を同様に示していたとも言えるが，その明快な説明は困難である。

また瞳孔の近見反応もAO無装着では反応の悪化が6例，一方AO装着では悪化は2例に過ぎなかった。また調節負荷を掛けていない瞳孔径ではAO無装着では散瞳4例，縮瞳1例，AO装着では散瞳は2例に過ぎなかった。瞳孔は自律神経を直接観察し得る部位であるが，散瞳，縮瞳とも自律神経の異常反応と考えてよく，AO装着でそれが防ぎ得たことを示していると考えられた。

低周波電磁波の健康障害性が種々議論されてきている。低周波電磁波が細胞レベルでカルシュウムの異常を生じる報告はすでに膨大な数にのぼっている[16]〜[19]。冨岡は100 kHzの電磁波曝露による水晶体のカルシュウム値の異常とそれに引き続く白内障を報告している[4]。このようなカルシュウムの異常は当然筋の緊張に異常をきたすのは予想される事でもあろう。

先にも述べたがAOは脳波の改善が知られている[7]。鶏胚の電磁波による死亡率の上昇も報告されているが，その死亡率はAOのアンテナから発生する微弱な補償電磁波によりほぼ防げる報告がある[20]。AOの有効性を

明らかに示す報告と言える。もちろん電磁波の発生，および漏洩しない電子機器の開発が望ましいことは言うまでもないが，現代社会でそれを望むことは困難であり，その生体障害性を防ぐ手段が要求される。その意味で今回の実験はCRT作業に伴う視覚系の障害の防御にAOの有用性を示し得たと考えられた。

V 要　　約

健常成人にAO無装着およびAO装着のTV画面で同一作業負荷4時間を掛け，その眼障害性を比較し次の結果を得た。

1) 角膜上皮症はAO装着によりAO無装着に比べて有意に減少していた。

2) AO装着により近点の延長が認められ，過去の報告と考え合わせて，調節の異常な緊張の発生を防止していると考えられた。

3) AO装着で調節のステップ応答での弛緩速度に遅れが認められた。

4) 近見時の瞳孔の異常もAO装着ではAO無装着に比べて少なかった。

以上よりVDT作業時におけるAOの有用性が示唆された。

キーワード：VDT, CRT, テクノAO, TECNO AO, 電磁波

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