Abnormal tear dynamics and symptoms of eyestrain in operators of visual display terminals

Hitoshi Nakaishi, Yuichi Yamada

Abstract

***Objectives*—To clarify the relation between the prevalence of dry eye syndrome and subjective symptoms of asthenopia in visual display terminal (VDT) operators.**

***Method*—722 VDT workers (242 subject workers with symptoms of asthenopia and 480 controls without such symptoms) without obvious organic ocular diseases received an ophthalmological examination consisting of refractometry and a tear function (phenol red thread) test.**

***Results*—More than 30% of symptomatic workers were found to meet the criteria of dry eye, and the odds ratio compared with the controls was 4.61 ($p<0.001$). This odds ratio was significantly greater than that obtained for refractive errors (2.31).**

***Conclusions*—Although this cross sectional study could not prove that dry eyes are the cause of asthenopia, the profound association of dry eyes with symptoms of asthenopia could be verified. It would be useful to carry out tear function tests in workers with symptoms of asthenopia.**

(*Occup Environ Med* 1999;**56**:6–9)

Keywords: visual display terminal; work; dry eye syndrome; asthenopia

Department of Hygiene, Occupational and Environmental Medicine, Kanazawa Medical University, Japan
H Nakaishi
Y Yamada

Department of Public Health, College of Medical Technology and Nursing, University of Tsukuba, Japan
H Nakaishi

Correspondence to:
Dr Hitoshi Nakaishi, Department of Hygiene, Occupational and Environmental Medicine, Kanazawa Medical University, Daigaku 1-1, Uchinada, Ishikawa Prefecture 920-02, Japan. Telephone 0081 76 286 2211; fax 0081 76 286 9723.

Accepted 15 August 1998

Numerous studies[1–6] have found a higher prevalence of symptoms of uncomfortable eyes among visual display terminal (VDT) operators compared with office workers doing comparative jobs not involving VDTs. Although the absolute values reported vary among authors, many report that >50% of VDT workers complain of eye discomfort.[7] Therefore, VDT work is recognised as a high risk factor for eye discomfort or asthenopia.

There are many factors which affect the visual comfort of VDT operators. Extrinsic factors include ergonomics of the VDT itself and the desk and chair with which it is used, sources of glare such as windows or lighting, ill defined job related pressures, and others.[8] In case these factors play the major part in asthenopia of VDT workers, they should be ergonomically improved. On the other hand, factors related to the visual system of each person, such as accommodation[9] (accommodation means the dynamic refraction by which the refractive power of the lens is changed so that a clear image of various objects is formed on the retina), discomfort related to vergion[10] (vergions are binocular, conjugate movements of the eyes allowing the lines of sight to move in a parallel direction), anisometropia (anisometropia is a condition in which there is a difference in the refractive error of the two eyes), or refractive miscorrection are also important. We have determined the refractive error to be probably the most common cause of symptoms of asthenopia among VDT operators and also have established an "expert system" for analysing the optimal visual conditions, especially the refractive conditions, for VDT operators.[11 12]

A reduced blinking rate and widening of the ocular surface due to the raising the viewing angle could cause symptoms of asthenopia among these workers, as could reduction of the stability of the precorneal tear film.[13 14] Toda *et al* reported that dry eyes comprise most of the symptoms of ocular fatigue.[15] However, these reports are based on the clinical data of patients presenting to a certain hospital, and as far as we could tell there are no reports that assess the relation between tear status and symptoms of asthenopia in many VDT workers.

Therefore, in the present study, we investigated the proportion of abnormal tear dynamics in VDT operators with symptoms of asthenopia with the cotton thread test.

Subjects and methods

All the employees belonging to one computer manufacturing company were asked to answer the questionnaire. In that company at the time of this study there were 3274 employees, of whom 1756 were men (mean age 33.4) and 1518 were women (mean age 28.3). In Japan there are no large scale computer manufacturing plants, so most of the employees work either in research and development or sales departments.

The questionnaire was distributed at the time of the periodic general physical check up carried out by the company for our study. It asked about (*a*) the status of visual correction, (*b*) the content of VDT work, (*c*) total working hours and average hours spent in VDT work each day during the past month, (*d*) previous and present illnesses or symptoms diagnosed by physicians and any current medications, (*e*) complaints about working conditions (table 1), and (*f*) occurrence and intensity of ocular and other physical discomforts during the past month (table 2).

In (*b*), the classification of VDT work was based on the recommendation in a report from the National Academy of Science in the United States,[16] which was composed of data entry, data acquisition, interactive communication—that is, a combination of data entry and data acquisition—word processing, and programming. The employees who answered to (*b*) that

Occup Environ Med: first published as 10.1136/oem.56.1.6 on 1 January 1999. Downloaded from http://oem.bmj.com/ on May 16, 2022 by guest. Protected by copyright.

Table 1 Questionnaire for complaints about working conditions

1	The time spent at a VDT is too long
2	Each working period at a VDT is too long
3	Breaks in the working period at a VDT are too seldom
4	Feel overloaded due to deadlines
5	Feel stressful due to monotonous task
6	Room illumination is too bright/dark
7	Screen is glittering or glaring
8	Noise in the workplace (from printer etc is too loud)
9	Air cooling and central heating of the workplace are extreme
10	Humidity of the workplace is too low
11	The height of chair is unadjustable
12	The backrest of chair is inappropriate
13	Space at the desk is inadequate
14	Space between lower leg and seat-pan is inappropriate

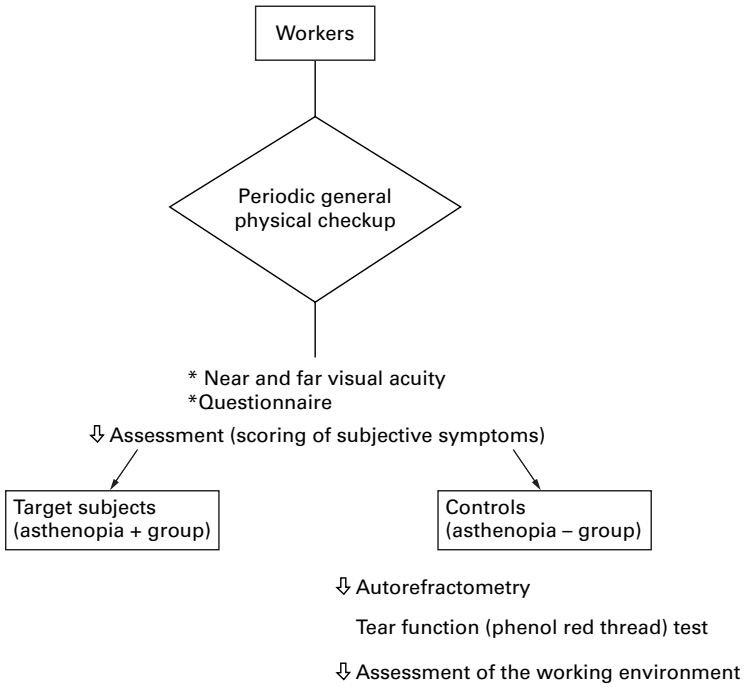
Table 2 Questionnaire for subjective symptoms

1	Ocular fatigue
2	Ocular pain
3	Double vision
4	Blurred vision
5	Dry sensation
6	Excess blinking
7	Headache
8	Irritation
9	Difficulty in falling asleep
10	Inadequate sleep
11	General fatigue not relieved by rest
12	Pain in hands or arms
13	Shoulder or neck stiffness
14	Shoulder or neck pain
15	Back pain
16	Lumbago
17	Others (if any)

they use VDTs more than 4 hours daily were considered eligible for this study.

The replies to the questions of (*e*) were divided into yes or no, and the replies to the questions of (*f*) were scored as follows: no or yes to some extent=1, yes definitely but can be endured=2, and yes definitely and unbearable=3.

Those with a total score of 32 or ranking at least one reply of 3 in the replies to the questions of (*f*) and free from any obvious organic ocular diseases (detected by the answer to (*d*)) were selected as the target subjects (VDT workers with asthenopia). This selection method is based originally on Suzumura's asthenopia study[17] and was slightly modified by us.[12]



Flow chart of the VDT study.

They received an ophthalmological examination consisting of visual acuity at both near and far distance, refractometry by autorefractometer, and tear function (phenol red thread) test.[18] To avoid any type of biases of data due to visual work load just before the examination, all examinations were carried out on a Monday morning before the start of work.

Refractive errors were defined according to Nakaishi and Miyao[12]—that is, presence of uncorrected hyperopia (≥+1.0 D for people <40 years old and ≥+0.5 D for people >40 years old), presence of uncorrected astigmatism (≥1.25 D for the axis of >30°, <60°~120°<,150°; ≥0.75 D for the axis of ≤30°~60°≤, ≤120°~150°), overcorrected myopia (≥+0.5 D with correction).

Tear function (phenol red thread) test was carried out according to the original method reported by Hamano *et al*.[18] A cotton thread stained with phenol red is inserted into the lower conjunctival sac through the eyelid instead of a filter paper strip in Schirmer's test. The cotton thread irritates the eye less than filter paper, and the test period is only 15 s. The test is performed without anesthesia on a closed eye. The cut off value we adopted was 10 mm/15 s. The definition of dry eye is based on the definition of Yamada *et al*[19] with slight modification—that is, either of the examinee's eyes exhibiting <10 mm or both eyes exhibiting no more than 10 mm by the phenol red thread test.

The controls consisted of colleagues of each subject failing to meet these criteria of subjective symptoms of asthenopia and working in the same workplace matched for age (within 3 years), sex, and status of visual correction (use of glasses, contact lenses, or no correction during VDT work). The controls also received the same ophthalmological examination as the subjects.

Several environmental characteristics in all the workplaces were assessed according to the company's standard[8] by industrial hygienists.

A flow chart of this study is shown in the figure.

Significance was tested by χ^2 test with StatView-J4.5 (Abacuus Concepts).

Results and discussion

This study was carried out with the assistance of not only representatives of the employers but also of the union, and the members of the company's occupational environmental health and safety (EHS) section. Hence, the response rate to the questionnaire was very high (99.7%; only 13 people refused to answer the questionnaire), so we can ignore selection bias in response to the questionnaire.

There were 242 eligible subjects (100 men, 142 women). Their mean age was 30.3, median 29, and mode 26.

Eighty two of these 242 subjects (33.9%) met the criteria of dry eyes, and refractive error was diagnosed in 60 subjects (24.8%).

Occup Environ Med: first published as 10.1136/oem.56.1.6 on 1 January 1999. Downloaded from http://oem.bmj.com/ on May 16, 2022 by guest. Protected by copyright.

Table 3 Prevalence (n (%)) of dry eye and refractive errors among 242 subjects and 480 controls, and their odds ratios (ORs)

	Asthenopia (+)	*Asthenopia (−)*
Dry eye (+)	82 (33.9)	48 (10.0)
Dry eye (−)	160 (66.1)	432 (90.0)
OR	4.61	
p Value	<0.01	
Refractive error (+)	60 (24.8)	60 (12.5)
Refractive error (−)	182 (75.2)	420 (87.5)
OR	2.31	
p Value	<0.01	

No clear relation between prevalence of dry eyes and age, sex, or corrective status (use of glasses, contact lenses, or no correction) was found.

On the other hand, only 48 of 480 controls satisfied the criteria of dry eyes (10.0%) with 60 people satisfying those of refractive errors (12.5%); the odds ratio was 4.61 ($p<0.001$) for dry eyes and 2.31 ($p<0.001$) for refractive errors (table 3).

The finding of a higher prevalence and thus high odds ratio of dry eyes among the subjects with symptoms of asthenopia compared with controls strongly suggests that we must take dry eye syndrome into consideration when we as occupational health practitioners encounter complaints among VDT workers (because in our study controls were selected to match working condition for every subject, bias due to the differences in the working environment can be ignored). Our data suggest that dry eyes might be a more common cause of, or at least more associated with, symptoms of asthenopia than refractive errors among VDT workers. As other researchers have mentioned,[15] our results indicate that dry eye syndrome and refractive errors might both be causes of asthenopia in VDT workers, rather than be mutually exclusive, for we found some degree of overlap between these conditions in the subjects (11 people) as well as in the controls (16 people).

There have been much experimental data supporting an increase in the prevalence of drying of the eyes,[13 20] as well as a report on dry eyes and VDT work in a clinical setting.[14] However, there have been no reports assessing the relation between tear status and subjective complaints in a large number of VDT workers. Our results, for the first time, indicate a higher prevalence of dry eye syndrome among VDT workers with asthenopia than among those without asthenopia in an actual working population.

One of the difficulties in analysing dry eye syndrome is that the definition of dry eye itself differs depending on the researcher, at least here in Japan; in 1992, dry eye syndrome was defined as a "quantitative or qualitative abnormality of tear irrespective of keratoconjunctival disorder" at a clinical conference held at Keio University. One author specified that disregard for keratoconjunctival lesions is unique to Japan.[19] However, in 1995, the Japan Dry Eye Research Group stated that the term dry eyes must include keratoconjunctival lesions[21]; the group classified those with only decreased tear secretion without any keratoconjunctival disorder as incomplete dry eyes or intermittent dry eyes and remarked that such a type of dry eyes may be associated with VDT work or use of contact lenses.[22] Our data relate to the conventional or incomplete type of dry eyes, because we did not confirm the corneal condition by slit lamp observation but only checked the condition of the tears.

Our data also support the general concept that ocular symptoms are associated with small refractive errors.[23–25] However, the odds ratio was smaller than that for dry eyes in our study. So we recommend investigation of not only refractive errors but also tear conditions when we encounter VDT workers with symptoms of asthenopia, or for the first stage of prevention, before they start VDT work. At least correction status and tear condition should be checked. For high risk prospective VDT workers (those with corrective errors or dry eyes), specific precautions should be taken—for example, making them wear more suitable glasses during VDT work or apply artificial tear solution as well as the usual action from the aspect of industrial health, to prevent the health problems of VDT work—such as, controlling working time, adjustment of ergonomic variables at the work stations, and controlling workplace humidity, temperature, and lighting.

1 Dainoff MJ, Happ A, Crane P. Visual fatigue and occupational stress in VDT operators. *Hum Factors* 1981;**23**:421–38.
2 Läubli T, Hunting W, Grandjean E. Postural and visual loads at VDT workplace. Lighting conditions and visual impairment. *Ergonomics* 1981;**24**:933–44.
3 Starr SJ, Thompson CR, Shute SJ. Effects of video display terminals on telephone operators. *Hum Factors* 1982;**24**: 699–711.
4 Yamamoto S, Visual, musculoskeletal and neuropsychological health complaints of workers using video-display terminal and an occupational health guideline. *Jpn J Ophthalmol* 1987;**31**:171–83.
5 Rossignol MA, Pechter ME, Summers VM, *et al*. Video display terminal use and reported health symptoms among Massachusetts clerical workers. *J Occup Med* 1987;**29**:112–18.
6 Collins MJ, Brown B, Bowman KJ, *et al*. Task variables and visual discomfort associated with the use of VDT's. *Optom Vis Sci* 1991;**68**:27–33.
7 Bergqvist UOV, Knave B. Eye discomfort and work with visual display terminals. *Scand J Work Environ Health* 1994; **20**:27–33.
8 Hewlett-Packard, EHS Group, VDT/Office Ergonomics. *Environmental, health and safety training.* New York: Hewlett-Packard, 1994:5961–7256.
9 Ishikawa S. Examination of the near triad in VDU operators. *Ergonomics* 1990;**33**:787–96.
10 Iwasaki T, Kurimoto S. Measurement of vergent eye movement by jumping method before and after VDT work. *Acta Ophthalmol* 1984;(suppl 164):24.
11 Nakaishi H. Implementation of ophthalmological tests in periodic eye checkups for VDT workers in Japan. *Safety Science* 1995;**20**:271–5.
12 Nakaishi H, Miyao M. Establishment of an expert system for visual display terminals (VDT) workers' periodic eye checkups. In: Anzai Y, Ogawa K, Mori H, ed. *Advances in human factors/ergonomics 20B*. Amsterdam: Elsevier, 1995: 599–604.
13 Patel S, Henderson R, Bradley L, *et al*. Effect of visual display unit use on blink rate and tear stability. *Optom Vis Sci* 1991;**68**:888–92.
14 Tsubota K, Nakamori K. Dry eyes and video display terminals. *N Engl J Med* 1993;**328**:584.
15 Toda I, Fujishima H, Tsubota K. Ocular fatigue is the major symptom of dry eye. *Acta Ophthalmologica* 1993 **71**:347–52.
16 Panel on Impact of Video Viewing on Vision of Workers. *Video displays, work and vision.* Washington, DC: National Academy Press, 1983.
17 Suzumura A. Diagnosis of asthenopia deduced from chief complaints. In: Mishima S, Tsukahara I, Uemura Y, eds. *Asthenopia.* Tokyo: Kinbara, 1985:1–9.
18 Hamano H, Hori M, Hamano T, *et al*. A new method for measuring tears. *CLAO J* 1983;**9**:281–9.
19 Yamada M, Yoshino K, Ono M, *et al*. Dry eye; its concept and definition. *Folia Ophthalmol Jpn* 1992;**43**:1289–93.
20 Yaginuma Y, Yamada H, Nagai H. Study of the relationship between lacrimation and blink in VDT work. *Ergonomics* 1990;**33**:799–809.

Occup Environ Med: first published as 10.1136/oem.56.1.6 on 1 January 1999. Downloaded from http://oem.bmj.com/ on May 16, 2022 by guest. Protected by copyright.

21 Japan Dry Eye Research Group. Definition and criteria of dry eye. *Ophthalmology (Japan)* 1995;**37**:765–70.
22 Farris RL. Contact lenses and the dry eye. *Int Ophthalmol Clin* 1994;**34**:129–36.
23 Dain SJ, McCarthy AK, Chan-Ling T. Symptoms in VDU operators. *Am J Optom Physiol Opt* 1988;**65**:162–7.
24 Daum KM, Good G, Tijerina L. Symptoms in video display terminal operators and the presence of small refractive errors. *J Am Optom Assoc* 1988;**59**:691–7.
25 Wiggins NP, Daum KM. Visual discomfort and astigmatic refractive errors in VDT use. *J Am Optom Assoc* 1991;**62**:680–4.

Occupational and Environmental Medicine - http://www.occenvmed.com

Visitors to the world wide web can now access Occupational and Environmental Medicine either through the BMJ Publishing Group's home page (http://www.bmjpg.com) or directly by using its individual URL (http://www.occenvmed.com). There they will find the following:

- Current contents list for the journal
- Contents lists of previous issues
- Members of the editorial board
- Subscribers' information
- Instructions for authors
- Details of reprint services.

A hotlink gives access to:

- BMJ Publishing Group home page
- British Medical Association website
- Online books catalogue
- BMJ Publishing Group books.

The web site is at a preliminary stage and there are plans to develop it into a more sophisticated site. Suggestions from visitors about features they would like to see are welcomed. They can be left via the opening page of the BMJ Publishing Group site or, alternatively, via the journal page, through "about this site".

Occup Environ Med: first published as 10.1136/oem.56.1.6 on 1 January 1999. Downloaded from http://oem.bmj.com/ on May 16, 2022 by guest. Protected by copyright.