# Prevalence of Dry Eye Disease and its Risk Factors in Visual Display Terminal Users: The Osaka Study

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• PURPOSE: **To investigate tear function and prevalence of dry eye disease (DED) in visual display terminal (VDT) users.**

• DESIGN: **Cross-sectional study.**

• METHODS: **Six hundred and seventy-two young and middle-aged Japanese office workers who used VDT completed questionnaires and underwent dry eye testing. We estimated the prevalence of DED using logistic regression analysis to examine associations between DED and possible risk factors. The ocular surface feature, prevalence of DED, and risk factors were evaluated.**

• RESULTS: **Of the 672 workers, 561 (83.5%, mean age: 43.3 ± 9.1 years) completed the questionnaire. The percentage of women with a composite outcome of definite DED or probable DED was 76.5%, which was higher than that among men (60.2%; odds ratio [OR] = 2.00; 95% confidence interval [CI], 1.29-3.10, $P = .002$). Workers over 30 years of age had a higher risk of DED (OR = 2.22; 95% CI, 1.06-4.66), as did workers using a VDT >8 hours per day (OR = 1.94; 95% CI, 1.22-3.09). Average Schirmer value was 18.7 ± 11.7 mm and tear break-up time (TBUT) was 4.0 ± 2.5 seconds (78.6% of study participants had TBUT ≤5 seconds).**

• CONCLUSIONS: **DED is prevalent among young to middle-aged Japanese VDT users. Ophthalmic findings revealed short TBUT and corneal staining accompanied by normal Schirmer test values. Increased risk for DED was noted for women aged over 30 years and prolonged VDT use. Measures to modify the adverse impact of VDT use on the ocular surface may provide a positive impact on public health and quality of life for office workers using VDTs. (Am J Ophthalmol 2013;156: 759–766. © 2013 by Elsevier Inc. All rights reserved.)**

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DRY EYE DISEASE (DED) IS AN IMPORTANT PUBLIC health problem causing ocular discomfort, fatigue, and visual disturbance that may interfere with daily activities.[1] Dry eye is one of the most prevalent eye diseases and reasons for seeking eye care.[2] Based on data from the largest epidemiologic studies of DED—the Women's Health Study and the Physicians' Health Study—it has been estimated that about 7.8% or 3.23 million American women and 4.7% or 1.6 million men over 50 years of age have DED.[3,4] Other studies have evaluated the prevalence of DED in different parts of the world.[5,6] It is thought that many people have less severe symptoms and probably a more episodic manifestation of DED that is noticed only during exposure to certain contributory factors such as visual display terminals (VDTs).[7,8]

Home use of computers and portable information terminals has risen steadily, and VDT exposure is increasingly common not only in VDT workers but also in the general population because of widespread use of mobile devices or smart phones among both young and old.

We previously reported the prevalence of DED in VDT users using a questionnaire-based assessment, and found that clinical diagnosis or severe symptoms were prevalent among young and middle-aged Japanese office workers.[9] Although there have been a number of largely anecdotal reports relating DED symptoms to VDT use, only a few studies have investigated tear function and estimation of the magnitude of the problem or risk factors that might be amenable to modification.[10,11] The authors therefore set out to investigate tear function and to estimate the prevalence of DED among Japanese office workers who use VDTs, and tried to identify key risk factors based on clinical examinations by dry eye specialists and implementing the latest version of the Japanese dry eye diagnostic criteria. The aims of this study were to study tear function, to estimate the prevalence of and factors associated with DED, and to evaluate its ocular manifestations in Japanese men and women who use VDTs.

## METHODS

• STUDY POPULATION: Under the supervision of the Japanese Dry Eye Society, the authors arbitrarily selected 2

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large companies listed on the Japanese stock market and sent a letter to the industrial physician of the health management section of each company to explain the purpose of the study and to request their participation. The only company in the pharmaceutical sector that responded to our letter and consented to participate was enrolled in this study. Following an internal review of the protocol and the consequences of the study, permission was granted to conduct the study in employees who were willing to participate. Subjects were invited by e-mail to answer the questionnaires and to attend a general ophthalmic check-up. A maximum of 2 e-mail reminders were sent. Subjects who reported a history of refractive surgery were excluded from the study protocol. This cross-sectional research followed the tenets of the Declaration of Helsinki, and the protocol was approved prospectively by the Institutional Review Board of Ryogoku Eye Clinic Tokyo, Japan.

• **QUESTIONNAIRE:** We administered a dry eye questionnaire widely used in Japan.[12] Briefly, the questionnaire includes 12 questions pertaining to the diagnostic symptoms of DED.[12] Possible answers to questions regarding symptoms included "constantly," "often," "sometimes," and "never." Subjects who responded to more than 1 of the 12 questions by "constantly" or "often" were considered positive for subjective symptoms of DED. Information on age, sex, and smoking (current smoker or not) was also obtained. Based on our previous studies,[9,13] we defined the duration of VDT use (stratified, none to over 10 hours in 1-hour categories) and contact lens (CL) use (yes or no). Past/current history of certain common systemic diseases (hypertension [HT], diabetes mellitus [DM]) was determined by asking participants whether they had ever been told of these conditions by their physician. We defined systemic medication use as medication prescribed only by a doctor, and not over-the-counter supplements.

• **CLINICAL EVALUATION:** *Tear function tests and ocular surface evaluation*. Ophthalmic examinations included assessment of conjunctival and corneal vital staining with lissamine green and fluorescein, tear break-up time (TBUT), and Schirmer test. The condition of the ocular surface was evaluated as reported previously.[14] Briefly, corneal and conjunctival epithelial damage was evaluated by the double vital staining method. Two microliters of a preservative-free combination of 1% lissamine green and 1% sodium fluorescein were instilled into the conjunctival sac by micropipette. To evaluate keratoconjunctival epithelial damage, the cornea and conjunctiva were assessed by fluorescein and lissamine green staining, respectively. The eye was categorized into 3 equal compartments representing nasal conjunctiva, cornea, and temporal conjunctiva, and the maximum staining score for each area was 3 points. Overall epithelial damage was scored on a scale of 0-9 points.

Tear stability and quantity were assessed by 2 different methods: TBUT and Schirmer test. To determine TBUT, fluorescein vital staining was performed; patients were requested to blink 3 times to ensure adequate mixing of the fluorescein dye with tears. The time interval between the last complete blink and the appearance of the first corneal dark spot was measured by stopwatch, with the mean of 3 measurements regarded as TBUT in this study. The Schirmer test was performed without topical anesthesia, following all other examinations. Strips (Whatman No.41; Showa, Tokyo, Japan) were placed for 5 minutes at the outer one third of the temporal lower conjunctival fornix. The strips were then removed, and the length of filter paper that had been wetted (in mm) was recorded. To avoid the influence of conjunctivocorneal staining on the Schirmer test, we proceeded with that test after a 10-minute interval. The grading of meibomian gland dysfunction (MGD) was performed according to modified Bron's classification,[15] as follows: grade 0, no glandular dropout and easy meibum expressibility with clear transparent meibomian secretion; grade 1, glandular dropout in one third of the eyelid length, with acinar cluster visibility in the remaining eyelid, granular secretion, difficult expressibility, turbid, nonsticky secretion; grade 2, glandular dropout in one third of the eyelid with loss of acinar cluster visibility but with observable yellow stripes, meibomian secretion not easily expressible, opaque, white granular secretion; grade 3, meibomian seborrhea with increased sticky secretion. All ophthalmic examinations were performed by ophthalmologists specializing in DED. To avoid the influence of air conditioning on TBUT and other dry eye tests, we did not use any air conditioner in the examination room. The room temperature was maintained at 25.0°C-26.5°C during examinations, with 60%-65% humidity. Subjects were not allowed to use a VDT for 1 hour prior to their examinations.

*Diagnosis of dry eye disease*. Diagnosis was established according to the Japanese dry eye diagnostic criteria, as follows: (1) presence of dry eye symptoms; (2) presence of qualitative or quantitative disturbance of the tear film in 1 or both eyes (Schirmer test ≤5mm or TBUT ≤5 seconds); and (3) presence of conjunctivocorneal epithelial damage (total staining score ≥3 points) in 1 or both eyes. The presence of all 3 criteria was necessary for a definite diagnosis of DED. Subjects showing the presence of 2 of the 3 criteria were diagnosed with probable DED, while those with 1 or no positive criteria were diagnosed as non-DED[16] (Table 1). With the aim of comparing differences between dry eye diagnosis in our study group and Japanese and international diagnostic criteria, we also implemented the Dry Eye WorkShop (DEWS) severity grading system[17] to assess differences in diagnosis.

• **STATISTICAL ANALYSIS:** To compare differences in the Schirmer test, TBUT, epithelial staining, and MGD

**TABLE 1.** The Dry Eye Diagnostic Criteria in Japan

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Symptoms of dry eye[a] | + | | − | + | + | + | − | − | − |
| Tear abnormality[b] | + | | + | − | + | − | + | − | − |
| Epithelial damage[c] | + | | + | + | − | − | − | + | − |
| Dry eye diagnosis | Definite dry eye disease | | Probable dry eye disease | | | Non–dry eye disease | | | |

+ = yes; − = no.

[a]At least 1 positive sign of dry eye questions.

[b]The presence of at least 1 positive criterion is essential: (1) Schirmer test-I ≤5 mm; or (2) TBUT ≤5 seconds.

[c]The presence of at least 1 positive criterion is essential: (1) total score of fluorescein ≥3 points; or (2) lisamine green staining ≥3 points.

grading between sexes, we used Student *t* test. The prevalence of DED was calculated and the corresponding 95% confidence interval (CI) estimated. Using a logistic regression model, we calculated odds ratios (ORs) and 95% CIs of DED for sex, demographic, lifestyle, and medical factors. First, we carried out univariate analyses of the associations between each factor and definite and probable DED. Then, mutual adjustment for all associated factors identified in univariate analyses ($P < .2$) was performed. Although the age category was not associated with diagnosis of DED in univariate analysis, we collapsed age into 2 categories (≤30 and >30 years) and included this variable in the multivariable models, since previous studies found age to be an important risk factor for DED.[18] We categorized prolonged VDT working hours as >8 hours, since the average was 7.9 hours for all subjects. *P* values of <.05 were considered to indicate statistically significant differences. All statistical analyses were performed using SAS software, version 9.2 (SAS Inc, Cary, North Carolina, USA).

## RESULTS

OF THE 672 OFFICE WORKERS APPROACHED, 561 (83.5%) participated in this study: 374 male (66.7%) and 187 female participants (33.3%) aged between 22 and 65 years (Table 2). Participants ranging in age from 30-49 years accounted for 68.8% of the study population. The mean duration of VDT use was 7.7 ± 2.1 hours among men and 8.3 ± 2.3 hours among women. Most workers were healthy, with only 14.4% reporting any type of systemic disease and 24.2% reporting the use of systemic medication.

The results of ocular findings are shown in Table 3. The average Schirmer test value was 16.7 ± 11.5 mm in men and 22.6 ± 11.2 mm in women, and 83.1% of all subjects had a Schirmer score >5 mm. Mean TBUT was 4.3 ± 2.7 seconds in men and 3.4 ± 1.9 seconds in women, and 78.6% of subjects showed a TBUT of ≤5 seconds. Most subjects scored low on epithelial staining: 471 of 561 (83.9%) under 3 points and only 1 patient (0.2%) with 7 points or over. Meibomian gland scoring showed that 279 of 374 (74.6%) in men and 154 of 187 (82.3%) in women were grade 0, with no statistically significant difference by sex ($P = .08$).

**TABLE 2.** Characteristics of the Study Population: Dry Eye Disease Among Visual Display Terminal Users

| Variables | Men (n = 374) n (%) | Women (n = 187) n (%) |
|---|---|---|
| Age (y) | | |
| 22-29 | 14 (3.7) | 20 (10.7) |
| 30-39 | 87 (23.3) | 68 (36.4) |
| 40-49 | 150 (40.1) | 81 (43.3) |
| 50-65 | 123 (32.9) | 18 (9.6) |
| Current smoker | 105 (28.1) | 5 (2.7) |
| VDT use (hours) | | |
| 0-4 | 55 (14.7) | 18 (9.5) |
| 4-8 | 246 (65.7) | 110 (58.8) |
| >8 | 73 (19.5) | 59 (31.5) |
| Contact lens user | 77 (20.6) | 93 (49.7) |
| Past/current history of certain common systemic diseases | | |
| Hypertension | 24 (6.4) | 3 (1.6) |
| Diabetes mellitus | 6 (1.6) | 0 (0.0) |

VDT = visual display terminal.

The prevalence of DED by sex is shown in Table 4. The proportion of women with a composite outcome of definite DED (18.7%) was higher than that of men (8.0%). Most instances of definite DED were seen among subjects who met the criteria of symptoms, epithelial damage, and TBUT ≤5 seconds. One hundred and ninety-five of 374 men (52.1%) and 108 of 187 women (57.8%) were diagnosed as having probable DED ($P = .24$). The majority of subjects with probable DED (70.3% of men and 85.2% of women) had symptoms and TBUT ≤5 seconds. The next most frequent group consisted of subjects with symptoms, TBUT ≤5 seconds, and an abnormal Schirmer value. The non-DED group was composed of 149 men (39.8%) and 44 women (23.5%), and 39.3% of this group had TBUT ≤5 seconds, followed by a group of subjects with symptoms only (26.9%).

The results of univariate and multivariate analysis of the associations between demographic, lifestyle, and medical factors and DED are shown in Table 5. According to the multivariate-adjusted model, factors associated at $P < .2$ with the composite outcome of definite or probable DED were female sex (OR = 2.00, 95% CI = 1.29-3.10, $P = .002$), age over 30 years (vs <30 years, OR = 2.22, 95%

**TABLE 3.** Detailed Ocular Finding Results in Visual Display Terminal Users

| | Men (n = 374) | Women (n = 187) | Total (n = 561) | *P* Value |
|---|---|---|---|---|
| Schirmer (mm) | | | | |
| >5 | 296 (79.1%) | 170 (90.9%) | 466 (83.1%) | .0001 |
| ≤5 | 78 (20.9%) | 17 (9.1%) | 95 (16.9%) | |
| Mean ± SD | 16.7 ± 11.5 | 22.6 ± 11.2 | 18.7 ± 11.7 | |
| TBUT (seconds) | | | | |
| >5 | 96 (25.7%) | 24 (12.8%) | 120 (21.4%) | .0005 |
| ≤5 | 278 (74.3%) | 163 (87.2%) | 441 (78.6%) | |
| Mean ± SD | 4.3 ± 2.7 | 3.4 ± 1.9 | 4.0 ± 2.5 | |
| Epithelial staining (points) | | | | |
| 0-2 | 327 (87.5%) | 144 (77.0%) | 471 (84.0%) | .001 |
| 3-6 | 46 (12.3%) | 43 (23.0%) | 89 (15.8%) | |
| 7-9 | 1 (0.2%) | 0 (0.0%) | 1 (0.2%) | |
| Mean ± SD | 1.0 ± 1.3 | 1.4 ± 1.4 | 1.1 ± 1.3 | |
| MGD (grade) | | | | |
| 0 | 279 (74.6%) | 154 (82.3%) | 433 (77.2%) | .084 |
| I | 69 (18.4%) | 19 (10.2%) | 88 (15.7%) | |
| II | 16 (4.3%) | 9 (4.8%) | 25 (4.4%) | |
| III | 10 (2.7%) | 5 (2.7%) | 15 (2.7%) | |

MGD = meibomian gland dysfunction; TBUT = tear break-up time.

CI = 1.06-4.66, $P = .04$), and prolonged VDT use >8 hours (vs short VDT use, ie, <8 hours, OR = 1.94, 95% CI = 1.22-3.09, $P = .005$). Although CL users comprised 30% of all subjects, we did not observe a significant association between CL use and the risk of DED in the multivariate model (OR = 1.13, 95% CI = 0.74-1.72, $P = .57$).

## DISCUSSION

DESPITE THE FREQUENCY WITH WHICH VDT WORKERS HAVE reported eye problems, large-scale studies delineating the risk factors associated with visual problems and symptoms of DED among workers who underwent clinical dry eye examination have not been published previously. This cross-sectional prevalence study was carried out to examine the prevalence of DED according to Japanese diagnostic criteria, with the chief aims of evaluating tear function, ocular surface status, and potential risk factors in office workers using VDT. The prevalence of definite DED was 8.0% in men and 18.7% in women based on clinical evaluation, while that of probable DED in men and women was 52.1% and 57.8%, respectively. Inter-sex differences were statistically significant, as well as age >30 years, and we further identified that workers using VDTs for ≥8 hours per day had a significantly increased risk of DED.

In the present study we used the Japanese criteria and performed both questionnaire-based assessment of symptoms and clinical dry eye examinations on all subjects, and surprisingly found the prevalence of definite and probable DED in those who had sought treatment as being twice that recorded in our previous work on VDT users, where the assessment of DED was based on questionnaire data only.[9] We believe that the dissimilarity in DED prevalence between these 2 study groups is likely attributable to differences between diagnostic criteria, since only 9.3% of subjects had symptoms of DED alone. These results imply that conducting clinical dry eye examinations in addition to questionnaires led to an increased prevalence of probable DED in young Japanese VDT workers compared with our previous estimate, which involved a dry eye questionnaire only.

This study also revealed that most subjects using VDTs had normal lacrimal function, according to Schirmer test results. These findings differ from those reported by Nakamura and associates, which suggested that cumulative years of VDT use might result in aqueous deficiency.[19] The present study did not measure the cumulative effect of prolonged VDT work, which may explain the differences between these observations. In regard to tear abnormalities, only a minority of subjects had a stable tear film: 74.3% of men and 87.2% of women had short TBUT values. In the DEWS report 2 subtypes of DED are noted, with evaporative DED, which are most commonly from MGD, as an integral part of the disease.[17] Recent paper has pointed out the high prevalence of MGD, in surveys of patients with DED and in general population.[20]

It has been hypothesized that excessive evaporation of tear fluid attributable to prolonged blinking intervals while gazing is a causative factor in VDT-associated dry eye.[21,22] Moreover, previous studies showed that VDT use increased

**TABLE 4.** Prevalence of Dry Eye Disease by Sex in Visual Display Terminal Users

| | Men (n = 374) | | Women (n = 187) | |
|---|---|---|---|---|
| | No. of DED | Prevalence (95% CI) | No. of DED | Prevalence (95% CI) |
| Definite dry eye disease | 30 | 8.0 (5.5-11.3) | 35 | 18.7 (13.4-25.1) |
| Symptom + epithelial damage + TBUT≤5 + Schirmer ≤5 | 9 | 2.4 (1.1-4.5) | 6 | 3.2 (1.2-6.9) |
| Symptom + epithelial damage + TBUT≤5 | 21 | 5.6 (3.5-8.5) | 29 | 15.5 (10.6-21.5) |
| Probable dry eye disease | 195 | 52.1 (46.9-57.3) | 108 | 57.8 (50.3-64.9) |
| Symptom + Schirmer ≤5 | 15 | 4.0 (2.3-6.5) | 0 | 0 (0-2.0) |
| Symptom + TBUT ≤5 | 137 | 36.6 (31.7-41.7) | 92 | 49.2 (41.8-56.6) |
| Symptom + TBUT ≤5 + Schirmer ≤5 | 27 | 7.2 (4.8-10.3) | 8 | 4.3 (1.9-8.3) |
| Epithelial damage + Schirmer ≤5 | 2 | 0.5 (0.1-1.9) | 0 | 0 (0-2.0) |
| Epithelial damage + TBUT ≤5 | 8 | 2.1 (0.9-4.2) | 7 | 3.7 (1.5-7.6) |
| Epithelial damage + TBUT ≤5 + Schirmer ≤5 | 3 | 0.8 (0.2-2.3) | 1 | 0.5 (0-2.9) |
| Symptom + Epithelial damage | 3 | 0.8 (0.2-2.3) | 0 | 0 (0-2.0) |
| Non–dry eye disease | 149 | 39.8 (34.8-45.0) | 44 | 23.5 (17.6-30.3) |
| Symptom only | 37 | 9.9 (7.1-13.4) | 15 | 8.0 (4.6-12.9) |
| Schirmer ≤5 only | 7 | 1.9 (0.8-3.8) | 0 | 0 (0-2.0) |
| TBUT ≤5 only | 58 | 15.5 (12.0-19.6) | 189 | 6 (5.8-14.8) |
| Schirmer ≤5 and TBUT ≤5 (normal in epithelial damage and symptom) | 15 | 4.0 (2.3-6.5) | 2 | 1.1 (0.1-3.8) |
| Epithelial damage only | 1 | 0.3 (0-1.5) | 0 | 0 (0-2.0) |
| Normal in 3 categories | 31 | 8.3 (5.7-11.6) | 9 | 4.8 (2.2-8.9) |

CI = confidence interval; DED = dry eye disease; TBUT = tear break-up time.

the proportion of incomplete blinks and accelerated evaporation of the tear film.[22,23] Although we did not measure average and incomplete blinking rates, it is suggested by our findings that tear function in VDT users may be affected by blink frequency and patterns inducing tear film instability, with a short TBUT as the probable cause of VDT-associated DED. Taking into consideration the distribution of tear function and symptoms in normal subjects, one may postulate that DED in VDT workers starts with a shortened TBUT, leading to the development of subjective symptoms. This hypothesis can be supported by the observation that the majority of subjects in this study with probable DED had a combination of DED symptoms and shortened TBUT.

Lacrimal gland function has been reported to decrease gradually with aging,[24] resulting in reduced tear secretion and DED in the elderly; some studies showed a higher prevalence of DED in elderly populations.[25–27] However, in this study no age-related trend was observed in relation to the prevalence of DED in either sex, though the subjects were younger than in most other studies. This is likely attributable to our study population's consisting of relatively young individuals and few subjects over 60 years.

It has also been reported in previous studies that medication use in HT is a risk factor for DED,[3,26,27] and that HT can be a predictor of DED. One recent study found a marginally increased risk of DED associated with the use of diuretics but a decreased risk with the use of ACE inhibitors.[27] Although we failed to identify such an association among this group of younger male VDT users, since few subjects had HT, the power to detect such an association was low. The sex-related difference found in the prevalence of DED may be attributable to differences in the way that hormonal profiles change with age between men and women.[28] Although previous studies showed an association between depression and DED, in this study we did not observe any subjects who had been diagnosed with depression.[29,30]

In this study we employed corneal fluorescein staining, TBUT, and Schirmer testing to evaluate the ocular surface and tear function, since these are the essential procedures for diagnosis of DED in Japan. It should be noted that corneal fluorescein staining has been reported to have poor sensitivity and may be absent in approximately 40%-50% of mild to moderate DED cases.[31,32] In addition, TBUT and Schirmer tests have also been suggested as having poor specificity[31] in regard to the diagnosis of DED. In order to avoid these problems as far as possible in our study, we implemented the Japanese diagnostic criteria, which require the results of not only tear abnormality but also epithelial damage and symptom assessment. If the results of the current study are viewed according to the DEWS severity grading based on Schirmer, TBUT, and vital staining, we can claim that 58.1% of the subjects in our study were diagnosed with grade 1 DED severity, 8.3% grade 2, and 4.6% grade 3. A previous study showed work productivity loss from DED.[33] Our results showed that the office workers who spend long hours viewing

**TABLE 5.** The Associations Between Demographic, Lifestyle, and Medical Factors and Dry Eye Disease

| Variables | Prevalence (%) | Crude OR (95% CI) | *P* Value | Multi-adjusted OR (95% CI)[a] | *P* Value |
|---|---|---|---|---|---|
| Sex | | | | | |
| Men | 60.2 (225/374) | 1.00 | - | 1.00 | - |
| Women | 76.5 | 2.15 (1.45-3.20) | .001 | 2.00 (1.29-3.10) | .002 |
| Age (y) | | | | | |
| 22-29 | 55.9 (19/34) | 1.00 | - | 1.00 | - |
| ≥30 | 66.2 (349/527) | 1.55 (0.77-3.12) | .22 | 2.22 (1.06-4.66) | .04 |
| Current smoker (no or yes) | | | | | |
| No | 67.4 (304/451) | 1.00 | - | 1.00 | - |
| Yes | 58.2 (64/110) | 0.67 (0.44-1.03) | .07 | 0.86 (0.54-1.35) | .50 |
| VDT use (hours) | | | | | |
| 0-8 | 62.0 | 1.00 | - | 1.00 | - |
| ≥8 | 77.3 | 2.08 (1.33-3.27) | .001 | 1.94 (1.22-3.09) | .005 |
| Contact lens use (no or yes) | | | | | |
| No | 63.4 | 1.00 | - | 1.00 | - |
| Yes | 70.6 | 1.38 (0.94-2.04) | .10 | 1.13 (0.74-1.72) | .57 |
| Past/current history of certain common systemic diseases (no or yes) | | | | | |
| Systemic disease | | | | | |
| No | 65.2 | 1.00 | - | - | - |
| Yes | 67.9 (55/ 81) | 1.13 (0.68-1.87) | .64 | - | - |
| Hypertension | | | | | |
| No | 65.9 | 1.00 | - | - | - |
| Yes | 59.3 (16/27) | 0.75 (0.34-1.65) | .48 | - | - |

CI = confidence interval; OR = odds ratio; VDT = visual display terminal.
[a]Adjusted for age and all of the associated factors identified in the univariate analyses ($P < .2$).

VDT develop DED. Therefore, one may suggest that there is a necessity of improving the ergonomics of the work environment to prevent the development of DED.

We would like to emphasize the potential limitations of our study, which are as follows: First, the study was based on a self-administered questionnaire, which might have introduced bias regarding misunderstandings about the answers relating to medication use and subjects' health status. Second, the current study lacked information about the percentage of pre- and postmenopausal participants, status of menopause, and use of hormone replacement therapy, which have been widely accepted as being related to DED; and about the use of tear supplements such as artificial tears. It should also be noted that the use of such medications may reduce DED symptoms, and therefore their use may not have reflected subjects' level of symptoms. A third possible limitation is that a break of only 1 hour was allowed in VDT usage prior to clinical examinations. Because of the brief nature of the timing relating to the VDT task, we may not have measured the actual impact of VDT in a clinical setting, which might be permanent or task related. Fourth, information on confounding factors for DED reported in previous studies, such as passive smoking, work environment parameters, lifestyle, and continued or intermittent VDT use, was not obtained in this study. Such limitations should be carefully considered during the carrying out of epidemiologic studies such as this. Since the average VDT work span is around 8 hours, we could not evaluate the appropriate time span of VDT usage that would not induce DED. Therefore, we need further study focusing on subjects working fewer hours on VDTs. Although symptoms have been considered to be an important component of DED, recent studies have reported a high prevalence of subjects with objective evidence of DED who are asymptomatic employing commonly used instruments to assess distress.[34,35] In fact, 1 paper has reported that over 40% of subjects with DED may be asymptomatic.[34] So the requirement of symptoms in Japanese diagnostic criteria to diagnose DED might have underestimated the prevalence of DED significantly, which is another limitation of the current study.

Finally, since this was a cross-sectional study, further studies are required to determine the temporal association between individual factors and DED, as well as to further elucidate the mechanism of short TBUT in VDT users. It would be of interest to determine whether modifications in the work environment, such as VDT usage duration, temperature, humidity, and work tasks, might alter the prevalence of DED and the risk of development of short TBUT.

In summary, this epidemiologic study in Japan showed a high prevalence of definite and probable dry eye in relatively young VDT users using clinical dry eye evaluations,

with the majority of subjects having short TBUT without abnormal tear secretion or obvious ocular surface staining. Female sex, age, and VDT usage of over 8 hours were identified as risk factors for definite and probable DED. We hope these data from our study will provide an enhanced understanding of DED to clinicians and researchers and help develop more targeted interventions for patients with DED.

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## Biosketch

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