

DED was higher in smokers compared to non-smokers. Severe symptoms of DED did not relate to pack-years of cigarette smoking (OR=0.98, CI = 0.73-1.33). However, CL wearers were more likely to report severe symptoms of DED (OR= 3.61, CI = 3.05-4.28, $P<0.001$) in this study.

Severe Symptoms or Clinically Diagnosed DED

Consistent with our findings for the endpoints of clinically diagnosed DED and severe symptoms of DED, more women than men had the combined endpoint of either severe symptoms of DED or a history of clinically diagnosed DED (OR = 1.73, CI = 1.44-2.08, $P < 0.001$, Table 5). In this population of relatively young office workers, we did not observe a significant trend in relation to age and severe symptoms DED or clinically diagnosed DED. On the other hand, a significant trend was observed in relation to the duration of VDT work and expression of severe symptoms DED or clinically diagnosed DED (OR = 1.69, CI = 1.39 - 2.16 for <2 hours vs >4 hours, $P_{\text{trend}} < 0.001$). CL wear was the only other factor significantly associated with the combined endpoint of severe symptoms or clinically diagnosed DED (OR = 3.65, CI = 3.11- 4.29, $P = < 0.001$). The presence of systemic diseases, systemic medication use, smoking history, pack-years of cigarette smoking, type of VDT work, and environmental factors did not show any significant relation with the combined endpoint of severe symptoms DED or clinically

diagnosed DED (each $P > 0.40$).

Discussion

Despite the commonness with which VDT workers have complained of eye problems, large scale studies delineating the risk factors associated with visual problems and symptoms of DED among these workers have not been published so far. We carried out this cross-sectional prevalence survey to examine the prevalence of severe dry eye symptomatology and clinically diagnosed DED, and to evaluate potential risk factors in office workers using VDTs.

Dry eye disease is characterized by symptoms of ocular dryness and discomfort, and has previously been shown to have an effect on functional visual acuity¹⁴ and a significant impact on the ability to work, read, or use computers¹¹. Dry eye has also been reported to be a common cause of, or at least associated with, greater symptoms of asthenopia among VDT workers^{3,4,10-13}. Although clinical observations have long suggested that VDT users may be at increased risk of DED⁵, there are a few epidemiological data available to describe the magnitude of the problem¹¹.

Our study used a previously published questionnaire^{7,15} to enable a straightforward comparison with epidemiological data on DED in the US. Somewhat surprisingly, given the relatively young age of our study population, we found DED to be relatively common among Japanese male and female VDT workers. The prevalence estimates for

clinically diagnosed DED in this study were 10.1% in male and 21.5% in female subjects. The estimates for severe symptoms of DED were 27.3% in male and 48.0% in female participants.

Females in this study had a higher prevalence of clinically diagnosed DED (OR=1.69) and severe symptoms of DED (OR=1.64) compared to men.

In addition, although assessed using the same questionnaire, the prevalence of DED was higher among these female Japanese office workers than that found in the U.S.

Women's Health Study⁷. That study included nearly 40,000 US female health professionals aged 50 and older and found a prevalence of severe dry eye symptomatology of 3.4%, and of clinically diagnosed DED of 6.1%. However, it is unclear how many of those women may have used VDTs or for what duration. The prevalence of DED in participants of the Physician's Health Study was 3.9% among men 50 to 54 years old (Milijanovic BM, Dana MR, Sullivan DA. Prevalence and risk factors for dry eye syndrome among older men in the United States. ARVO abstract.2007). Although the population of Japanese VDT users was relatively young, the prevalence of DED in our study was higher compared to the Women's Health Study⁷ and Physician's Health Study⁵. The prevalence rates of one or more six dry eye symptoms in a population based study in Indonesia was 27.5%¹⁶. The prevalence rates of

DED in a Chinese population over 65 years was 23.5% in Shihpai Eye Study¹⁷. These might implicate potential racial differences with DED being more common in people of Asian ethnicity.

Dry eye has been reported to be a frequent disorder in the elderly in many population-based studies^{18,19}. Several lines of evidence support the hypothesis that the incidence of DED increases with age^{20,21}. Therefore, the observation of an inverse trend in our study such that older people were less likely to have dry eye disease was unexpected. It could be that older subjects in this study did not use VDTs as long as the younger subjects. It could also be that subjects who developed dry eye disease were no longer able to continue in a job that required VDT use. Other explanations might be that older subjects could be using medical ophthalmic services less or less likely reporting their symptoms since they might have had other systemic problems.

Longer durations of VDT work were observed to be associated with a significant trend toward higher prevalence of dry eye symptomatology and clinically diagnosed DED in both male and female VDT users. VDT work has been reported to be associated with lower blinking rates and increased tear evaporation with adverse effects on tear stability inducing short BUT type of DED²². The position of computer screen is believed to be an important factor in this sense since lowering the screen level has been reported to

reduce the over all ocular surface area and decrease the tear evaporation²². However, we did not observe any statistically significant impact of terminal position on risk of DED in this cohort. The only VDT related factor that was associated with DED was the duration of VDT use, which was found to be a significant factor related to severe symptoms of DED in our study, and might have important implications in terms of office environment adjustments, especially in female workers, who appear to be at higher risk of DED. Relevant measures might include limitation of VDT working hours per day, establishment of resting periods between two long duration VDT tasks, brief eye resting during a VDT task, allocation of non VDT tasks after a long VDT work, education of office workers on the aforementioned preventive measures related to DED including not using CL during VDT work.

The current study revealed that CL wear was a major risk factor related to clinically diagnosed and severe symptoms of DED in VDT workers. A normal tear film has been reported to be critical for successful contact lens wear²³⁻²⁵. Disturbances of the quantity or quality of the tear film, whether because of aqueous deficiency or evaporative tear problems²⁴, results in intolerance of contact lens wear and damage to the ocular surface²³. Of importance, was our observation that CL users who worked with VDT showed a significantly higher prevalence of clinically diagnosed DED and

severe symptoms of DED compared with VDT workers who did not wear CL.

A limitation of the current survey was that the subjects were not examined clinically for dry eye. However, the questionnaire approach we used was previously found to have a high level of sensitivity and specificity for identifying patients with DED⁹.

Nonetheless, although the questionnaire had a high level of validity when administered to health professionals, we employed it in a general population of workers in the pharmaceutical industry. Although these subjects may also have a relatively higher amount of health knowledge than a general population sample, it is not clear whether the survey would have the same level of discriminative ability among these workers as it had among participants in the Women's and Physicians' Health Studies..

In summary, DED was significantly more prevalent among female office workers and CL users. There was no age trend in relation to clinically diagnosed DED and severe symptoms of DED. Using a VDT for more than 4 hours a day was associated with a higher prevalence of severe symptoms of DED and also showed a significantly higher prevalence in subjects with severe symptoms DED or clinically diagnosed DED. Our present study represents the largest epidemiologic data from Japan describing the prevalence of dry eye syndrome in VDT users and its relationship to the aforementioned risk factors. Although further studies are needed to increase our understanding of the

significance of this important public health problem, the results of our study may be of guidance for specific precautions such as brief periods of rest during VDT work, provision of information and guidance on CL wear related problems and adoption of relevant policies in work places to be taken to prevent the ophthalmic disorders such as dry eyes emerging during VDT work.

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1 **Japan Ministry of Health Study on Prevalence of Dry Eye Disease Among**
2 **Japanese High School Students**

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1 Introduction

2 The report of the definition and classification subcommittee of the international
3 dry eye workshop, describes dry eye as follows: “Dry eye is a multifactorial disease of
4 the tears and the ocular surface that result in symptoms of discomfort, visual
5 disturbance, and tear film instability with potential damage to the ocular surface¹.”
6 Based on data from the largest epidemiological studies of dry eye to date, the Women’s
7 Health Study² (WHS), and the Physicians Health Study³ (PHS), and other studies⁴⁻¹³, it
8 has been estimated that about 3.23 million women and 1.68 million men, for a total of
9 4.91 million Americans 50 years and older have dry eye disease^{2,3}. Tens of millions or
10 more have less severe symptoms and probably a more episodic manifestation of the
11 disease that is notable only during exposure to some adverse contributing factors, such
12 as low humidity or contact lens wear. Comparison of age-specific data on the
13 prevalence of dry eye from large epidemiological studies reveals a range of about 5%¹¹
14 to over 35%¹² at various ages. Most of these studies involve relatively older populations
15 above 40 years of age²⁻¹³. The only large epidemiological study on a relatively young
16 population above 21 years of age from Sumatra reported the prevalence of DED as
17 27.5%¹³.

18 A PubMed and Medline search using the keywords “Dry eye”, “Children”,

1 “Pediatric”, “Adolescence”, “High school”, and “Juvenile” revealed that there are no
2 large scale studies involving young populations.

3 In this study, we aimed to clarify the prevalence of dry eye disease and CL wear
4 among Japanese high private school students aged between 15 to 18 years.

1 Subjects and Methods

2 Upon requested of Keio University health support center to investigate the
3 prevalence of DED and CL use in high school students, we sent out letters to the
4 principals of four Keio University affiliated private high school and four other private
5 high school located in Tokyo, Japan. The letter explained the purpose of the study and
6 requested the participation of consenting subjects. After a single mailed request, all four
7 Keio University affiliated private high school and one out of four Tokyo district private
8 high schools consented to the study. Of these five schools, four schools were only for
9 boys and one school was only for girls. 3433 students were requested and consented to
10 answer to the questionnaires sent by post mail. 3433 (100%) returned the questionnaires,
11 including 2848 males and 585 females.

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1 Questionnaires

2 We used the short dry eye questionnaire developed and validated by
3 Schaumberg et al ^{2,14,15}. We fully translated Schaumberg's questionnaire from English
4 into Japanese, and verified the translation by a back translation from the Japanese to
5 into English. The questionnaire includes three questions pertaining to the diagnosis and
6 symptoms of DED. Briefly, Schaumberg's questionnaire consisted of the following
7 question items (1) have you ever been diagnosed by a clinician as having dry eye
8 syndrome? (2) how often do your eyes feel dry (not wet enough)? , and (3) how often
9 do your eyes feel irritated? Possible answers to the two questions about symptoms
10 included "constantly," "often," "sometimes," or "never." To facilitate comparisons,
11 we defined DED similar to another large cohort as the presence of either a previous
12 clinical diagnosis of DED or severe symptoms (both dryness and irritation either
13 constantly or often) ^{2,15,16}.

14 Following administration of Schaumberg's questionnaire, we asked about the
15 presence of CL use. In relation to CL use, we asked the type of CL as SCL and HCL.
16 CL use was defined as "wear for a minimum of 12 hours per day".

17

1 Statistical Analysis

2 We performed all analyses with the SAS system V9.1 (SAS Institute Inc., Cary,
3 North Carolina, USA). We calculated the prevalence of DED in the study population
4 and estimated the corresponding 95% confidence interval (CI) using the binomial
5 distribution. To determine predictors of clinically diagnosed DED and severe symptoms
6 of DED, we fitted both univariate and multivariate logistic regression models.

7 Among ordinal variables, we also tested for linear trend across categories by
8 including an ordinal predictor variable a separate in the model. We used regression
9 diagnostic analyses to evaluate the fit of the final model. Two-tailed *P*-values of less
10 than 0.05 were considered to indicate a statistically significant difference.

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1 Result

2 Of the 3433 participants, all (100%) returned the questionnaires, including 2848
3 males (74.4%) and 585 females (25.6%). The participants ranged from 15 to 18 years of
4 age.

5 Clinically diagnosed dry eye syndromes

6 1.86 times as many females compared to males had a history of clinically
7 diagnosed dry eye (Table 1). SCL wear was associated with a significantly higher
8 prevalence in both males (OR=4.21 CI = 2.85-6.22, $p<0.001$, Table 2) and females
9 (OR=4.88 CI = 2.31-10.35, $p<0.001$, Table 2) clinically diagnosed with dry eye disease.
10 HCL wear was also associated with a significantly higher prevalence in both males
11 (OR=4.63 CI = 1.36-15.81, $p<0.001$, Table 2) and females (OR=2.51 CI = 0.51-12.24,
12 $p<0.001$, Table 2).

13 Severe dry eye symptomatology

14 Approximately 1.16 times as many female subjects compared to males
15 complained of severe dry eye symptomatology in this study (Table 1). There was a
16 significant relation between gender and severe symptoms DED (OR = 1.16, $P < 0.001$,
17 Table1).

18 CL wear was associated with a significantly higher prevalence of severe dry eye