RESEARCH REPORT

Possible association between heavy computer users and glaucomatous visual field abnormalities: a cross sectional study in Japanese workers

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Study objective: To study the association between computer use and visual field abnormalities (VFA) and to assess whether heavy computer users have an increased risk of glaucoma.
Design: Cross sectional multicentre study.
Subjects and observation procedures: A total of 10 202 randomly selected Japanese workers (mean (SD) age 43.2 (9.8) years) were screened for VFA using the frequency doubling technology perimetry (FDT-VFA), in addition to undergoing a general medical check up, and then ophthalmologically examined. Information about their computer use and refractive errors was obtained from a questionnaire and interview, respectively.
Main results: As a result of FDT test, 522 and 8602 subjects were positive and negative for FDT-VFA, respectively. A significant ($p=0.004$) interaction was found between computer use and refractive errors regarding the risk of FDT-VFA. In stratified analysis, heavy computer users with refractive errors showed a significant positive association with FDT-VFA (odds ratio (OR) = 1.74, 95% confidence interval (CI) 1.28 to 2.37), while those without refractive errors did not. Comparison of 165 subjects with an ophthalmological diagnosis of glaucoma and 2918 controls showed that the OR for glaucoma of heavy computer users with refractive errors was 1.82 (95% CI 1.06 to 3.12). Of 165 subjects with glaucoma, 141 had refractive errors, especially myopia (96.4%, 136 of 141).
Conclusions: Although there are limitations to this study, such as its cross sectional design, heavy computer users with refractive errors seem to have an increased risk of FDT-VFA. Glaucoma might be involved in an underlying disease and myopia in a risk factor for FDT-VFA.

A revolution in information technology (IT) is occurring worldwide at an extremely rapid pace. Many workers now obtain a large amount of information from visual display terminals (VDTs) during general duties as well as when performing specific jobs. Even in private life, an increasingly long duration of computer use is spreading explosively among every generation. Regarding VDT workers, much concern about psychological and physiological health has been raised.[1] Accordingly, we consider that it is crucial to identify health impairment in persons with a very long duration of computer use (heavy computer users).

Glaucoma, particularly open angle glaucoma (OAG), is a widely prevalent disease that manifests very slowly with age related progressive visual field abnormalities (VFA).[2] Although the aetiology of OAG remains unclear, numerous potential risk factors have been identified in addition to ocular hypertension, including certain diseases and lifestyle related conditions: vasospasm,[3] migraine,[4] tobacco smoking,[5] high blood viscosity,[6] sleep apnea syndrome,[7] hypertension,[5] psychological disturbance,[8] and myopia.[9] We postulated that heavy computer use may influence some of the risk factors for OAG, such as the lifestyle and the physical and psychological status, leading to an increased risk of glaucoma.

However, there are several problems to be solved before investigation of the association between computer use and glaucoma. Firstly, more than 50% and 75% of glaucoma was reported to be undiagnosed in western countries,[10 11] and Japan,[12] respectively. Thus, hospital based studies might have serious biases for investigation of risk factors related to glaucoma, indicating that population based studies are essential. Secondly, there is no ideal screening method for glaucoma, particularly normal tension glaucoma,[13] and there is no worldwide diagnostic standard for population based studies.[14] Thirdly, the assessment of exposure to long term computer stress is very difficult as there is no established method of quantitative measurement. Computer stress is influenced by complex factors such as the purpose of computer use, the environment, the equipment, and the continuous duration of use.[15] Also, the human-computer interface and equipment are evolving day by day.

Visual field testing by frequency doubling technology (FDT) perimetry permits the detection of glaucomatous VFA with a high degree of accuracy.[16–19] Our previous population based study showed that FDT perimetry could be a useful method of screening for glaucoma.[20] In this study, therefore, we analysed the results of FDT perimetry and ophthalmological examinations to investigate the possible association between heavy computer users and glaucoma.

METHODS

Study population and observation procedures

This study was performed at four institutions with large workforces (>5000 employees) in Japan, and most workers

Abbreviations: VFA, visual field abnormality; FDT, frequency doubling technology; IT, information technology; BMI, body mass index; VDT, visual display terminal; OAG, open angle glaucoma; SAP, standard automated perimetry

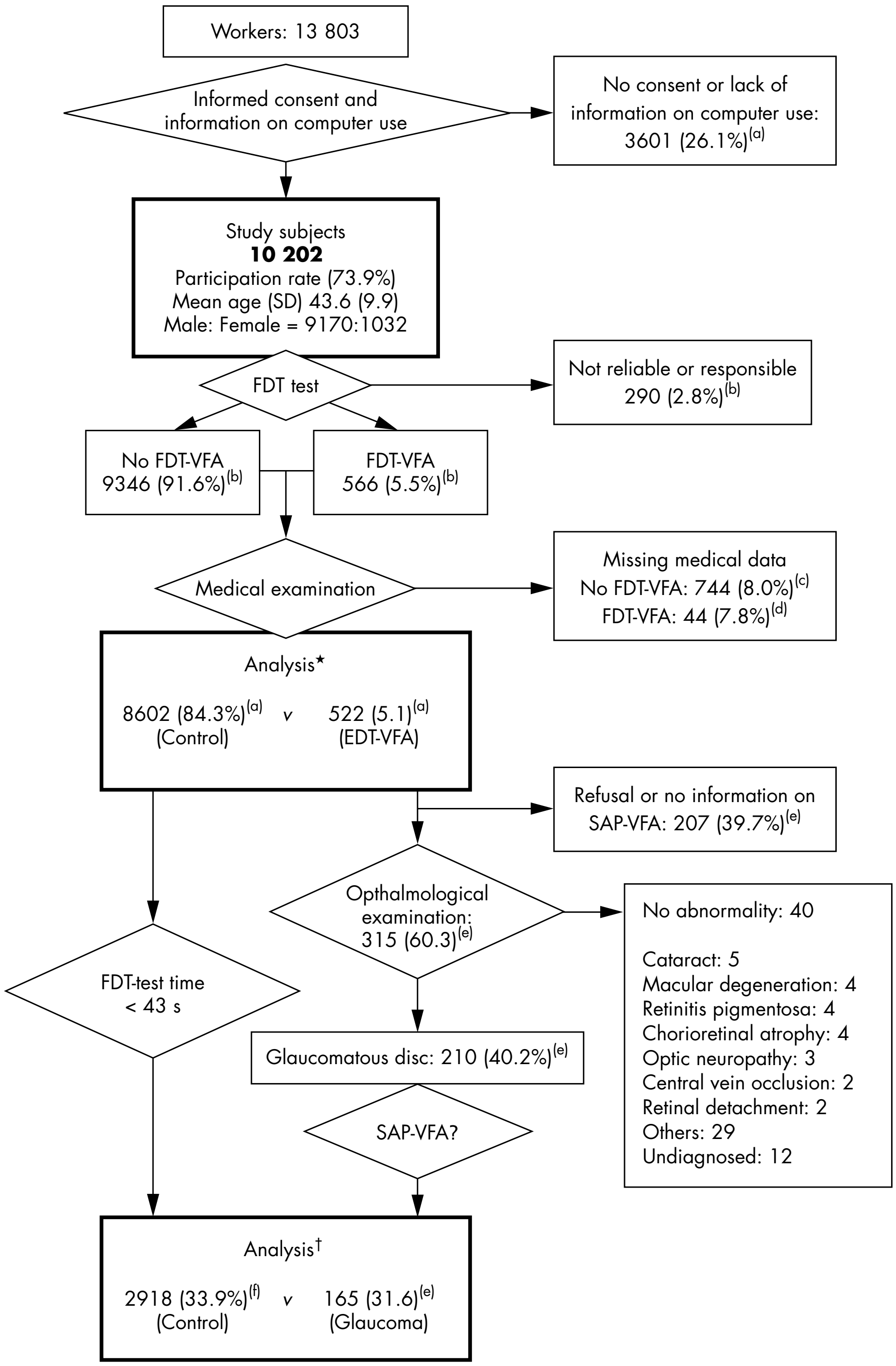

Figure 1 Flow of the subjects. Subjects were randomly selected from four large institutions. All participants completed a self administered questionnaire about computer use. Visual field testing by frequency doubling technology (FDT) perimetry was performed together with a medical check up. Subjects with visual field abnormalities detected by FDT perimetry (FDT-VFA) underwent detailed ophthalmological examination. A diagnosis of glaucoma was made when visual field abnormalities were detected by standard automated perimetry (SAP-VFA) and there were no abnormalities on ophthalomoscopy other than glaucomatous disc changes. Controls were selected from among subjects who completed FDT perimetry within 43 seconds for each eye, because a prolonged FDT test time is a good marker for the presence of SAP-VFA. Percentages indicate the proportion of subjects among the following populations: (a) 13 803, (b) 10 202, (c) 9346, (d) 566, (e) 522, and (f) 8,602. Analysis: Investigation of possible associations between computer use and FDT-VFA* or glaucoma†.

were involved in the electronics and steel industries. We assumed that workers in these institutions exhibited a representative work style for the past several decades in Japan. Two companies were located in metropolitan areas and two were in the suburbs. To randomly choose participants, they were selected according to their date of birth at three centres and according to their company ID number at one centre. The subjects were recruited from May to October 2000. Each subject gave written informed consent to participation in this study, which was also approved by the respective institutional ethics committees or corresponding committees. The participants underwent a general medical check up. Their examination included determination of visual acuity, checking for presence of refractive errors (use of eyeglasses or contact lenses), blood pressure measurement, haematology screening tests, and biochemistry tests.

In addition, all participants completed a self administered questionnaire about their private life and working style, including a history of ocular disease (retinal detachment, diabetic retinopathy, cataract, ocular hypertension, and glaucoma), a family history of glaucoma, symptoms of migraine, smoking habits, alcohol consumption, and computer use. Information concerning computer use included the subject's history of computer use, the mean daily time (both privately and at work) spent using computers for the past five years, the present level of use.

Table 1 Characteristics of subjects by status of FDT-VFA

	FDT-VFA (+) n = 522	FDT-VFA (−) n = 8602	p Value
Age (y)			
20–29	22 (4.2)	837 (9.7)	
30–39	100 (19.2)	2418 (28.1)	
40–49	195 (37.4)	2878 (33.5)	
50–59	178 (34.1)	2201 (25.6)	
60–	27 (5.2)	268 (3.1)	<0.001*
Mean (SD)	46.3 (8.8)	43.0 (9.8)	<0.001†
Sex			
Male	486 (93.1)	7766 (90.3)	0.057*

Data in parentheses are percentages unless stated otherwise. *χ^2 Test; †non-paired test. FDT-VFA, visual field abnormalities detected by frequency doubling technology perimetry.

FDT test and ophthalmological diagnosis

The visual field test using FDT perimetry are described elsewhere.[20 21] Briefly, both eyes were tested with an FDT perimeter (Carl Zeiss Meditec) in screening mode C-20-1 (version 2.6), according to the manufacturer's protocol. The test was carried out with subjects wearing their usual eyeglasses or contact lenses, because it has been reported that FDT does not require correction of refraction and that myopia does not influence the results of testing.[22] The reliability criteria for the FDT test were set at a false positive rate of one third or less and fixation errors of one third or less. When any grade of VFA was detected by the initial FDT test, retesting was performed to assess the reproducibility of the result. VFA of any grade and at any location were defined as FDT-VFA.

Subjects with FDT-VFA underwent ophthalmological examination. Glaucoma specialists performed these examinations at local hospitals. To unify the diagnostic process among several centres, final diagnosis was performed with blinding to information about computer use and other glaucoma risk factors. Three glaucoma specialists made the diagnosis on the basis of centrally corrected standard automated perimetry data and systematic review of the information on glaucomatous disc findings—that is, a cup to disc ratio >0.7, the presence of disc haemorrhage, notching of the disc, nerve fibre bundle defects, and peripapillary atrophy. A diagnosis of glaucoma was made when VFA were detected by standard automated perimetry (SAP-VFA) and there were no abnormalities on ophthalomoscopy other than glaucomatous disc findings. We defined VFA as SAP-VFA according to Anderson's criteria,[23] which were detected with the Humphrey Field Analyser central 30-2, Iester's method using an Octopus perimeter (INTERZEAG, Schlieren, Switzerland),[24] and the Rotterdam study method using a Goldmann perimeter.[25]

Classification of computer users

Based on information regarding the history of computer use, the subjects were divided into four categories that were assigned the scores in parentheses: <5 years (1), 5–10 years (2), 10–20 years (3), and >20 years (4). The mean daily time spent at the computer for the past five years was also divided into four categories and scored as follows: <1 hours (1), 1–4 hours (2), 4–8 hours (3), and >8 hours (4). Then we established a computer use index according to the following formula:

Computer use index = history of computer use (1–4) × mean daily time spent at the computer over five years (1–4). Subjects were classified into the following three groups according to this computer use index: 1–3, light users; 4–8, moderate users; and 9–16, heavy users.

Statistical analysis

All statistical tests were performed using SPSS 10.1 J (SPSS Japan, Tokyo). Differences of percentages and mean values among the groups were assessed using the χ^2 test and one way analysis of variance with Bonferroni's multiple comparison method, respectively. The age adjusted prevalence of FDT-VFA was compared among workers at the four centres using analysis of covariance. The odds ratio was calculated by unconditional logistic regression analysis. We screened for potential confounders and glaucoma risk factors identified in the literature.[2–9] The significance of the interaction between computer use and these risk factors for glaucoma was determined by comparing the model of computer use × respective variable with the model that assessed the main effect only.

Table 2 Odds ratio and 95% confidence intervals (CI) of variables potentially associated with FDT-VFA

Independent variable	FDT-VFA (+) n (%)	FDT-VFA (−) n (%)	Age and sex adjusted Odds ratio	Age and sex adjusted 95%CI	Multi-variable adjusted* Odds ratio	Multi-variable adjusted* 95%CI
BMI (kg/cm^2)						
−19.9	69 (13.2)	1123 (13.1)	1.00	(reference)	1.00	(reference)
20–25.9	366 (70.1)	5998 (69.7)	0.81	0.62 to 1.07	0.82	0.62 to 1.11
26–	78 (16.7)	1481 (17.2)	0.78	0.56 to 1.10	0.81	0.57 to 1.14
Ocular hypertension						
None	467 (91.4)	8145 (96.5)	1.00	(reference)	1.00	(reference)
Present	44 (8.6)	297 (3.5)	2.36	1.70 to 3.30	1.99	1.40 to 2.83
Family history						
None	459 (90.7)	7841 (93.4)	1.00	(reference)	1.00	(reference)
Present	47 (9.3)	555 (6.6)	1.38	1.01 to 1.88	1.33	0.96 to 1.83
Smoking						
Never	241 (46.4)	3673 (42.9)	1.00	(reference)	1.00	(reference)
Former or current	278 (53.6)	4896 (57.1)	0.78	0.65 to 0.94	0.82	0.68 to 0.99
Refractive errors						
None	106 (20.3)	3533 (41.1)	1.00	(reference)	1.00	(reference)
Present	416 (79.7)	5069 (58.9)	2.88	2.32 to 3.59	2.89	2.29 to 3.64
Computer use						
Light users	171 (32.8)	3173 (36.9)	1.00	(reference)	1.00	(reference)
Moderate users	252 (48.3)	4082 (47.5)	1.27	1.04 to 1.56	1.14	0.92 to 1.42
Heavy users	99 (19.0)	1347 (15.7)	1.58	1.21 to 2.05	1.38	1.05 to 1.82
			p for trend<0.001			

*Adjusted for listed all variables. FDT-VFA, visual field abnormalities detected by frequency doubling technology perimetry; BMI, body mass index.

Table 3 Adjusted* odds ratios and 95% confidence intervals (CIs) for the association between computer use and FDT-VFA in subjects with and without refractive errors

	Subjects with refractive errors				Subjects without refractive errors				
	FDT-VFA (+) n (%)	FDT-VFA(−) n (%)	Odds ratio	95%CI	FDT-VFA (+) n (%)	FDT-VFA(−) n (%)	Odds ratio	95%CI	p for interaction†
Computer use									
Light users	108 (26.0)	1530 (30.2)	1.00	(reference)	63 (59.4)	1643 (46.5)	1.00	(reference)	
Moderate users	216 (51.9)	2629 (51.9)	1.34	1.04 to 1.73	36 (34.0)	1453 (41.1)	0.74	0.48 to 1.15	0.004
Heavy users	92 (22.1)	910 (18.0)	1.74	1.28 to 2.37	7 (6.6)	437 (12.4)	0.45	0.19 to 1.06	
Total	416	5069	p for trend <0.001		106	3533			

*Adjusted by unconditional logistic analysis for age, sex, body mass index, ocular hypertension, family history, and smoking habit. †Significance of interaction was determined using the model with computer use × refractive errors term to the model with main effects only. FDT-VFA, visual field abnormalities detected by frequency doubling technology perimetry.

RESULTS

Figure 1 summarises the flow of subjects. Among the 13 803 available subjects, 10 202 (73.9%) agreed to participate in this study (mean age (SD), 43.6 (9.9) years; male:female = 9170:1032). There was no significant difference in participation rate between the two industries or locations. Although the age adjusted prevalence of FDT-VFA among workers at the four centres was significantly ($p<0.05$) different, ranged from 4.7% to 6.7%, it was always closely correlated with computer use (Peason's correlation coefficient = 0.990 ($p<0.01$)). This suggests that we could rule out an unknown factor unique to these centres other than computer use. In addition, our study protocol was strictly standardised among centres. Thus we analysed pooled data.

Among the 10 202 subjects, 566 subjects (5.5%) had FDT-VFA (mean age (SD), 46.5 (8.7); male:female = 523:43), while 9346 had no FDT-VFA. The remaining 290 (2.8%) subjects were excluded from the study, because they did not satisfy the reliability criteria of the FDT test or reproducibility. Complete medical data were available for 522 subjects with FDT-VFA and 8602 without FDT-VFA, and their characteristics are summarised in table 1. The mean age and the proportion of men among the subjects with FDT-VFA were significantly ($p<0.001$) greater and different with a borderline significance ($p = 0.057$), respectively, when compared with those without FDT-VFA.

According to their computer use, subjects were classified into light, moderate, and heavy computer users (n = 3344, 4334, and 1446, respectively). The mean (SD) age of each group was 44.7 (11.0), 42.5 (9.4), and 42.0 (7.1) years, while there were 3003 (89.8%), 3906 (90.1%), and 1,343 (92.9%) men, respectively. The three groups differed significantly

Table 4 Odds ratio and 95% confidence intervals (CI) for the association of computer use and other possible risk factors with glaucoma

	Glaucoma (+)	Glaucoma (−)	Age and sex adjusted		Multi-variable adjusted*	
Independent variable	n (%)	n (%)	Odds ratio	95%CI	Odds ratio	95%CI
BMI (kg/cm^2)						
−19.9	19 (11.5)	322 (11.0)	1.00	(reference)	1.00	(reference)
20–25.9	121 (73.3)	2057 (70.5)	0.68	0.41 to 1.14	0.67	0.38 to 1.16
26–	25 (15.2)	539 (18.5)	0.52	0.28 to 0.98	0.48	0.24 to 0.96
Systolic blood pressure (mm Hg)						
−99	6 (3.6)	128 (4.4)	1.00	(reference)	1.00	(reference)
100–139	133 (80.6)	2449 (83.9)	0.88	0.37 to 2.07	1.04	0.43 to 2.53
140–	26(15.8)	341 (11.7)	0.86	0.34 to 2.19	1.05	0.39 to 2.82
Ocular hypertension						
None	147 (90.2)	2774 (97.0)	1.00	(reference)	1.00	(reference)
Present	16 (9.8)	86 (3.0)	2.88	1.63 to 5.10	2.20	1.18 to 4.12
Family history						
None	149 (93.1)	2662 (93.6)	1.00	(reference)	1.00	(reference)
Present	11 (6.9)	182 (6.4)	1.02	0.54 to 1.92	0.74	0.36 to 1.50
Symptom of migraine						
No–occasionally	126 (77.8)	2369 (82.2)	1.00	(reference)	1.00	(reference)
Frequently–always	36 (22.2)	513 (17.8)	1.59	1.08 to 2.36	1.70	1.13 to 2.55
Smoking						
Never	76 (46.3)	1234 (42.2)	1.00	(reference)	1.00	(reference)
Former or current	88 (53.7)	1674 (57.6)	0.75	0.54 to 1.03	0.77	0.55 to 1.10
Alcohol consumption						
0 day/week	17 (10.4)	258 (8.9)	1.00	(reference)	1.00	(reference)
1–4 days/week	64 (39.0)	1312 (45.0)	0.85	0.49 to 1.49	0.78	0.44 to 1.40
5 days/week–	83 (50.6)	1344 (46.1)	0.78	0.45 to 1.35	0.78	0.44 to 1.39
Refractive errors						
None	24 (14.5)	1247 (42.7)	1.00	(reference)	1.00	(reference)
Present	141 (85.5)	1671 (57.3)	4.87	3.13 to 7.59	4.26	2.71 to 6.68
Computer use						
Light users	47 (28.5)	941 (32.2)	1.00	(reference)	1.00	(reference)
Moderate users	78 (47.3)	1466 (50.2)	1.31	0.90 to 1.92	1.18	0.78 to 1.79
Heavy users	40 (24.2)	511 (17.5)	2.11	1.34 to 3.31	1.66	1.02 to 2.71

*Adjusted for listed all variables. BMI, body mass index.

with respect to their mean age and sex ($p<0.001$ and $p<0.01$, respectively), with the heavy computer users being youngest and having highest male ratio.

The age and sex adjusted odds ratios for the systolic blood pressure, diastolic blood pressure, packed cell volume, haemoglobin, haemoglobin A_{1c}, alcohol intake, and history of migraine were not significant. In contrast, the age and sex adjusted odds ratios for ocular hypertension, a family history of glaucoma, smoking, and refractive errors were significant (table 2). Body mass index (BMI) showed a borderline inverse association with FDT-VFA. Using age, sex, and the other significant or borderline variables, multivariate logistic regression analysis was performed (table 2). Heavy computer users were shown to be significantly associated with FDT-VFA (odds ratio (OR) = 1.38, 95% confidence intervals (CI) = 1.05 to 1.82)

In addition, we investigated the interaction between computer use and risk factors for glaucoma in relation to FDT-VFA. Interestingly we found that refractive errors had a significant ($p = 0.004$) interaction effect. Thus we investigated the association between computer use and FDT-VFA using stratified analysis by the refractive errors status (table 3). After adjusting for potential confounding factors, heavy computer users with refractive errors showed a significant association with FDT-VFA, but those without refractive errors did not have an increased risk of FDT-VFA.

Of 522 subjects with FDT-VFA, a total of 315 (60.3%) agreed to undergo complete ophthalmological examination (responders). There were no significant differences of age, computer use, refractive errors, or family history of glaucoma between the responders and non-responders. However, the prevalence of ocular hypertension was significantly ($p<0.05$) lower in the responders than in the non-responders. Among these 315 subjects, 90.2% (275 of 305, because 10 had missing data) had minus diopters. Figure 1 shows the ophthalmological diagnoses. A total of 165 (31.6%, 165 of 522) subjects were suspected of having glaucoma, based on the presence of distinct SAP-VFA (139 by Humphrey Field Analyser, 23 by Octopus, and three by Goldmann perimetry) and glaucomatous disc findings. Of these 165 subjects, 141 (85.5%) had refractive errors and 152 (92.1%) had an intraocular pressure of less than 21 mm Hg at the first examination. Of the 141 subjects with refractive errors, 136 (96.4%) had minus diopters, and 83 (58.9%) had severe myopia of less than −6 diopters.

We performed a preliminary assessment of the possible association between heavy computer users and glaucoma. It has been reported that the FDT testing time is a good marker for the detection of SAP-VFA, as it should take less than 90 seconds to test FDT in both eyes without SAP-VFA.[19] In our study, all subjects having no ophthalmological abnormalities completed the test within 43 seconds for each eye (data not shown). We compared the 165 glaucomatous subjects (mean age; 47.4 (7.4) years) with 2918 (33.9%, 2918 of 8602) control subjects (mean age; 41.7 (9.8) years) who finished tests on each eye within 43 seconds. After adjusting for possible risk factors,[2–9] in addition to potential confounding factors, heavy computer users showed a significant association with glaucoma (OR = 1.66, 95% CI = 1.02 to 2.71) in table 4. After controlling for confounding factors, the OR of heavy computer users for glaucoma was 1.82 (95% CI = 1.06 to 3.12) in subjects with refractive errors versus 1.07 (95% CI = 0.26 to 4.31) in subjects without refractive errors.

DISCUSSION

Heavy computer users are highly concerned about ocular disorders, so a number of studies have been conducted to identify possible ocular disorders in this population.[26–28] To the best of our knowledge, however, this is the first study on VFA in heavy computer users that used highly sensitive perimetry to assess a large number of subjects. In addition to FDT perimetric test, we examined physical characteristics and lifestyle related parameters to identify potential confounding factors in our study population.

When interpreting results obtained in the workplace, we must always take into consideration the presence of selection bias. Therefore, we attempted to diminish such bias by conducting a multicentre study on a large number of subjects who were randomly selected in representative companies. However, before the IT revolution, male heavy computer users in the companies were generally limited to persons who had higher education or special skills such as systems engineers, programmers, and designers. Consequently, a classification based on computer use was a potential cause of bias. In fact, it seemed that heavy computer users without refractive errors had a decreased risk for FDT-VFA, and that heavy computer users had a lower incidence of other ocular diseases such as cataract and diabetic retinopathy. We considered that this was a result of bias—that is, a kind of healthy worker effect, since highly educated subjects tend to be more concerned about their health.[29–31] Thus, we investigated the interaction of risk factors for glaucoma with the occurrence of FDT-VFA in heavy computer users, and found that the association between heavy computer users and FDT-VFA was influenced by a significant interaction with refractive errors. We considered that self selection bias and information bias would not be important in this study because myopia is not a well known risk factor for glaucoma among the general population[9] and no information on the relation between myopia and glaucoma was given to our subjects. In addition, information on the history of computer use was obtained before testing to detect VFA. Therefore, the interaction with refractive errors suggests the existence of an association between heavy computer users and FDT-VFA, rather than being caused by such potential biases.

Further extensive efforts are needed to identify the involvement of glaucoma in the underlying diseases associated with VFA in heavy computer users. The precise diagnosis of glaucoma requires confirmation of the progression of VFA. Our data may have some biases because 40% of the subjects with FDT-VFA did not undergo a complete ophthalmological investigation and control subjects were not selected on the basis of a detailed ophthalmological examination. Non-responders exhibited a higher rate of

Key points

- In the general workforce in Japan, a positive statistical interaction was found between a history of computer use and refractive errors with respect to the risk of visual field abnormalities detected by the frequency doubling technology perimetry test (FDT-VFA).
- Myopic workers with a history of long term computer using might have an increased risk of visual field abnormalities, possibly related to glaucoma.

Policy implication

Occupational health personnel may need to monitor the prevalence of myopia and visual field abnormalities in the general workforce.

ocular hypertension compared with responders, suggesting that responders may have been biased towards normal tension glaucoma. However, our data strongly suggest that refractive errors are important with respect to the possible association between heavy computer users and VFA, and that myopia is the main form of refractive errors. Our results showed that age, BMI, ocular hypertension, family history for glaucoma, and smoking habit (never smoker) were possible confounding factors for FDT-VFA. Age, ocular hypertension, and family history of glaucoma are well defined risk factors for glaucoma.[2] Obesity and tobacco smoking have been reported to be possible risk factors for an increase in intraocular pressure or primary open angle glaucoma,[5 32 33] whereas, in this study, BMI and smoking were inversely associated with the risk of FDT-VFA. Among Japanese, normal tension glaucoma accounts for more than 75% of glaucoma,[12] and this study showed that more than 90% of glaucoma patients had a normal intraocular pressure. This distribution is quite different from that in western populations.[10 11] The previously reported risk factors for OAG are often contradictory, and ethnicity is an important determinant of its risk factors.[2] Thus, BMI and smoking might be involved in the progression of glaucomatous VFA differently between different ethnic groups or between subtypes of glaucoma, or both.

Recent studies have suggested that myopia is a potent risk factor for OAG with a high intraocular pressure[9] and with a normal pressure.[34] A number of mechanisms have been postulated. Sharing forces in myopic eyes might cause structural weakness of the optic disc, fluctuation of intraocular pressure, and microcirculatory disturbance.[35] The relation between myopia and computer stress has been debated for decades.[26] Use of a VDT might influence physical and mental health problems such as blood pressure and mood disturbance,[36 37] which have been reported as possible risk factors for glaucoma.[8] These findings lead us to speculate that the optic nerve in myopic eyes might be structurally much more susceptible to computer stress than in non-myopic eyes, along with certain changes of the physical and/or mental risk factors for glaucoma in heavy computer users.

This study used the computer use index to estimate computer stress, which was developed with reference to the smoking (Brinkman) index.[38] We classified the subjects into three groups on the basis of computer use index values, but this may be criticised because valuable statistical information can be lost if interval or ordinal scaled data on small classes are transformed in ordinal scaled data on large classes. The problems relating to assessment of exposure to computer stress were mentioned earlier, and the validity cannot be accurately verified for computer stress. Accordingly the compute use index with its narrow scale (numerical variable) cannot exactly represent the extent of long term computer stress, so we believe that it is reasonable to transform this numerical variable into an order variable with a larger scale for investigation of the possible association between heavy computer users and FDT-VFA.

This study had several limitations. Firstly, our study design was cross sectional. Secondly, comparatively few women were studied because male employees comprise most of the Japanese workforce. Thirdly, refractive errors were not determined ophthalomogically in all participants. Finally, it is difficult to obtain a precise family history of glaucoma because a large number of glaucoma patients are undiagnosed.[12] These limitations indicate the need for further studies to confirm our findings. Computer stress is reaching higher levels than have ever been experienced before. In the next decade, therefore, it might be important for public health professionals to show more concern about myopia and VFA in heavy computer users.

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THE *JECH* GALLERY

Schools in socially contrasting neighbourhoods

These two photographs display contrasts in the appearance of two primary schools in Glasgow city. Both schools are state funded and come under the auspices of the same local authority, but one is located in a more affluent area, the other in a more deprived area. Lower self esteem and aspirations for the future have been observed among residents of the more deprived area compared with the more affluent area. Could the physical appearance of schools be partly associated with this?

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