

Association Between Duration of Daily VDT Use and Subjective Symptoms

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Background Although visual display terminal (VDT) work has become a common task among office workers, surveys which would help to determine the allowable duration of daily VDT use are limited.

Methods We investigated more than 25,000 workers three times over a 3-year period using a self-administered questionnaire. Three factors, namely mental, physical and sleep-related symptoms, were extracted by factor analysis. Adjusted means of each factor score were compared with the duration of daily VDT use by general linear model.

Results Physical symptoms score became higher with increasing duration of daily VDT use without a threshold effect. Mental and sleep-related symptom scores of the workers using VDT for more 5 hr/day were significantly higher than that of the groups using VDT for >1, 1–3, and 3–5 hr/day.

Conclusions Duration of daily VDT use was linearly related to the physical symptom score, and was non-linearly related to mental and sleep-related symptom score with a threshold effect of 5 hr/day. Am. J. Ind. Med. 42:421–426, 2002. © 2002 Wiley-Liss, Inc.

KEY WORDS: visual display; terminal; subjective symptoms; dose-effect relationship; disorder of sleep; Japanese workers

INTRODUCTION

Visual display terminal (VDT) use in the office environment was formerly confined to specialized user groups. However, with the spread of personal computers, VDTs have been introduced to many situations in the workplace and accordingly the number of VDT workers has increased.

To protect workers from adverse effects of VDT work, the Japanese Ministry of Labour published guidelines for

VDT work [Japanese Ministry of Labour, 1984]. The World Health Organization also published a report investigating psychosocial aspects and health of VDTs in the workplace and provided some recommendations concerning the use and system design of VDTs [World Health Organization, 1989]. Both suggested the need to develop job designs which include minimization of VDT use duration. In addition, some studies confirmed the relationships between VDT use and physical symptoms [Starr, 1983; Knave et al., 1985; Shimai et al., 1986; Rossignol et al., 1987; Shima et al., 1993; Bernard et al., 1994; Marcus and Gerr, 1996; Rechichi et al., 1996; Polanyi et al., 1997] or mental symptoms [Hayashi and Matsumoto, 1985; Watanabe, 1986; Lindstrom, 1991; Mino et al., 1993; Tachibana et al., 1998] although significant symptoms varied with reports. Some studies have failed to observe a significant relationship between VDT use and physical symptoms [Sugita et al., 1986; Fahrback and Chapman, 1990] or mental symptoms [Starr et al., 1982, 1985; Sauter et al., 1983; Starr, 1984; Tarumi et al., 1990]. However, a few studies have reported a positive relationship

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[Rossignol et al., 1987; Polanyi et al., 1997] or mental symptoms. Consequently, a reduction or limitation of daily VDT use is recommended, but the relationship between VDT use, especially duration thereof, and subjective symptoms is still unclear.

To improve the design of VDT work, investigations providing reliable evidence are required. Therefore, we conducted a survey which considered confounding factors, three times over a three-year period in a group of over 25,000 workers to clarify the relationship between subjective symptoms and duration of daily VDT use, and attempted to find evidence supporting a limit of allowable daily VDT use.

MATERIALS AND METHODS

Subjects

The subjects consisted of office workers of an information technology company in Japan, and were of age 20–59 years. After excluding workers who did not use VDTs, the sample consisted of 29,711 in 1995, 28,760 in 1996, and 25,964 in 1997. The participation rate for the annual health examination was more than 90% in each year. Almost all of the workers in the study were clerical workers engaged in sales, customer services, accounting, planning, and general affairs. The workers belonging to the design division which used computer aided design (CAD), programming division and research and development division were not included in this study. The workers engaged in data entry throughout the day were also not included.

Subjective Symptoms

Seventeen subjective symptoms were adopted from the items of the checklist of subjective symptoms in the annual health examination: headache, eyestrain, arthralgia, stiff shoulders, low back pain, sensory disturbance, general fatigue, disorder of initiating sleep, frequent sleep interruption, early morning waking, lethargy, anxiety, difficulty getting along with coworkers, depressive feeling, (feeling of) absence of adviser, reluctance to go to work, and difficulty in enjoying life. The possible answers of each subjective symptom consisted of not at all, occasionally, and always, which were scored as 0, 1, and 2, respectively.

Duration of Daily VDT Use

Duration of daily VDT use was evaluated by a self-administered questionnaire at the annual health examination. Subjects were divided into four groups according to duration of daily VDT use: <1, 1–3, 3–5, and >5 hr.

Work-Related Factors and Other Factors

Information on age, sex, daily working hours, monthly holidays, daily sleeping hours, and glasses or contact lens use were also requested on the self-administered questionnaire. Daily working hours were average working hours during the previous month, and included overtime work. Monthly holidays were the average number of days of weekends and paid holidays during the previous month. Daily sleeping hours were the average number of sleeping hours during the previous month. Daily working hours were categorized into three groups: <8, 8–12, and >12 hr. Monthly holidays were categorized into three groups: <4, 5–7, and >8 days. Daily sleeping hours were categorized into three groups: <5, 5–8, and >8 hr. Glasses or contact lens use were categorized into two groups: use and non-use.

Statistical Analysis

By a factor analysis for the items with varimax rotation, the factors with eigenvalues greater than 1.0 were extracted. Their internal consistency was confirmed by calculation of the reliability coefficients (Cronbach's alpha). The scores of the items which exhibited a factor loading of greater than 0.3 for each of the factors were summed.

Finally, the scores of factors were compared among the groups of duration of daily VDT use by Analysis of Covariate (ANCOVA) adjusting for age, daily working hours, monthly holidays, daily sleeping hours, and glasses or contact lens use.

All statistical analyses were performed by SPSS for Windows Release 10.0.7 J.

RESULTS

The distributions of age and work-related factors are presented in Table I. The prevalence of workers with symptoms are presented in Table II. The results of the factor analysis according to year are shown in Table III.

From the factor analysis of the subjective symptoms, three factors were extracted in each year. Each factor consisted of the same items in each year. Factor 1, mental symptoms; consisted of seven items, which were lethargy, anxiety, difficulty getting along with coworkers, depressive feeling, absence of adviser, reluctance to go to work and difficulty in enjoying life. Factor 2, physical symptoms; consisted of six items, which were headache, eyestrain, arthralgia, stiff shoulders, low back pain, and general fatigue. Factor 3, sleep related symptoms; consisted of disorder of initiating sleep, frequent sleep interruption, and early morning waking. Sensory disturbance was not incorporated into any of the factors in any examined year.

TABLE I. Characteristics of Subjects According to Sex and Year; VDT Users in Japan

Variables	Categories	Year					
		1995		1996		1997	
		Male	Female	Male	Female	Male	Female
Age (years old)	20–29	2,187	981	2,350	1,051	2,164	1,013
	30–39	5,787	1,251	5,301	841	4,754	647
	40–49	11,426	3,084	10,919	2,871	9,164	2,554
	50–59	4,034	961	4,479	948	4,719	949
Duration of daily VDT use (hr)	<1	7,258	1,121	6,413	1,016	4,697	741
	1–3	8,419	1,103	7,703	1,046	6,534	947
	3–5	4,206	1,666	4,438	1,143	4,578	1,116
	>5	3,551	2,387	4,495	2,506	4,992	2,359
Daily working hours (hr)	<8	7,808	3,961	7,511	3,406	6,320	2,976
	8–12	15,120	2,301	15,002	2,277	13,864	2,160
	>12	506	15	536	28	617	27
Monthly holidays (day)	<4	443	110	398	66	378	71
	5–7	5,682	740	5,236	586	5,032	514
	>8	17,309	5,427	17,415	5,059	15,391	4,578
Daily sleeping hours (hr)	<5	982	281	1,049	285	1,172	301
	5–8	21,656	5,781	21,196	5,275	18,976	4,735
	>8	796	215	804	151	653	127
Glasses or contact lens use	No	11,010	3,553	10,374	3,096	9,241	2,716
	Yes	12,254	2,673	12,567	2,588	11,456	2,412

TABLE II. Prevalence of VDT Users in Japan Having Symptoms According to Sex and Year

Variables	Year					
	1995		1996		1997	
	Male	Female	Male	Female	Male	Female
Headache	13.55	32.52	12.54	32.45	13.67	33.35
Eyestrain	38.61	52.73	37.51	52.97	38.72	54.54
Arthralgia	13.94	24.25	13.36	25.46	14.38	28.37
Stiff shoulders	21.75	34.28	20.95	32.60	20.77	31.96
Low back pain	10.81	16.44	10.28	15.51	10.43	16.06
Sensory disturbance	5.25	5.96	5.43	6.29	5.39	5.97
General fatigue	6.41	7.31	6.83	8.21	7.16	9.55
Disorder of initiating sleeping	5.58	6.07	5.18	6.01	5.01	6.45
Frequent sleep interruption	3.83	4.92	3.87	5.03	3.78	5.52
Early morning waking	4.30	2.26	4.36	2.00	4.37	2.50
Lethargy	5.18	5.64	4.75	5.41	4.99	4.84
Anxiety	4.17	5.48	3.75	4.40	3.61	4.76
Difficulty getting along with coworkers	1.31	1.37	1.03	1.28	1.15	1.49
Depressive feeling	2.96	4.32	2.71	3.55	2.75	4.36
Absence of adviser	1.13	0.59	1.05	0.70	1.17	0.68
Reluctance to go to work	8.89	9.37	7.95	8.42	8.44	8.81
Difficulty in enjoying life	1.72	1.85	1.78	1.38	2.12	1.82

The workers who answered occasionally and almost always were defined as workers who have a symptom.

TABLE III. Factor Loading Matrix After Varimax Rotation for Dataset; VDT Users in Japan

	1995			1996			1997		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
Headache	0.085	0.453	0.106	0.085	0.450	0.080	0.107	0.460	0.107
Eyestrain	0.082	0.533	0.100	0.076	0.536	0.103	0.094	0.543	0.110
Arthralgia	0.081	0.417	0.129	0.083	0.428	0.104	0.057	0.464	0.122
Stiff shoulders	0.034	0.353	0.008	0.025	0.347	0.020	0.018	0.310	0.010
Low back pain	0.046	0.365	0.029	0.044	0.363	0.038	0.050	0.358	0.013
Sensory disturbance	0.061	0.250	0.132	0.059	0.277	0.105	0.072	0.252	0.115
General fatigue	0.276	0.350	0.178	0.266	0.365	0.206	0.285	0.367	0.205
Disorder of initiating sleeping	0.123	0.136	0.454	0.146	0.137	0.470	0.153	0.123	0.424
Frequent sleep interruption	0.090	0.105	0.589	0.099	0.108	0.566	0.110	0.116	0.575
Early morning waking	0.124	0.107	0.350	0.101	0.096	0.328	0.114	0.086	0.362
Lethargy	0.437	0.217	0.155	0.440	0.228	0.180	0.427	0.213	0.183
Anxiety	0.510	0.108	0.136	0.519	0.128	0.119	0.510	0.131	0.119
Difficulty getting along with coworkers	0.511	0.025	0.038	0.480	0.025	0.035	0.526	0.027	0.042
Depressive feeling	0.635	0.125	0.110	0.641	0.115	0.107	0.642	0.120	0.123
Absence of adviser	0.464	0.025	0.038	0.484	0.019	0.068	0.471	0.013	0.088
Reluctance to go to work	0.390	0.264	0.157	0.405	0.252	0.178	0.419	0.265	0.163
Difficulty in enjoying life	0.551	0.062	0.111	0.586	0.049	0.113	0.598	0.066	0.119

Cronbach's alpha of mental symptoms, physical symptoms, and sleep related symptoms ranged from 0.69 to 0.71, from 0.54 to 0.55, and from 0.47 to 0.48, respectively. The results of the reliability test are shown in Table IV.

TABLE IV. Result of Reliability Test for Dataset

	Cronbach's alpha		
	1995	1996	1997
Factor 1: mental symptoms	0.685	0.697	0.705
Lethargy			
Anxiety			
Difficulty getting along with coworkers			
Depressive feeling			
Absence of adviser			
Reluctance to go out to work			
Difficulty in enjoying life			
Factor 2: physical symptoms	0.543	0.547	0.550
Headache			
Eyestrain			
Arthralgia			
Stiff shoulders			
Low back pain			
General fatigue			
Factor 3: sleep related symptoms	0.482	0.474	0.474
Disorder of initiating sleeping			
Frequent sleep interruption			
Early morning waking			

The results of the comparisons of adjusted mean of mental symptoms score, physical symptoms score, and sleep related symptoms score are shown in Table V. The Mental symptoms score and sleep related symptoms score of the workers using VDT more than five hours were significantly higher than those of groups using VDT for >1, 1–3, and 3–5 hr. On the other hand, the physical symptoms score elevated with increasing duration of daily VDT use with all of the differences between the groups being significant.

DISCUSSION

According to factor analysis, the seventeen subjective symptoms were divided into three categories, i.e., mental, physical, and sleep related symptoms. Cronbach's alpha was almost 0.7 for mental symptoms, and about 0.5 for physical and sleep related symptoms, suggesting sufficient reliability for our study.

Although several studies have suggested relationships between VDT use and subjective symptoms [Starr, 1983; Hayashi and Matsumoto, 1985; Knave et al., 1985; Shimai et al., 1986; Watanabe, 1986; Rossignol et al., 1987; Lindstrom, 1991; Mino et al., 1993; Shima et al., 1993; Bernard et al., 1994; Marcus and Gerr, 1996; Rechichi et al., 1996; Polanyi et al., 1997; Tachibana et al., 1998], some studies have failed to confirm it [Starr et al., 1982, 1985; Sauter et al., 1983; Starr, 1984; Sugita et al., 1986; Fahrbach and Chapman, 1990; Tarumi et al., 1990]. The reasons underlying this discrepancy are regarded to be insufficient sample size and a lack of control for confounding factors.

TABLE V. Comparison of Adjusted Mean of Symptoms Score According to Duration of Daily VDT Use

Indices	Year	Duration of daily VDT use							
		<1 hr		1–3 hr		3–5 hr		>5 hr	
		Adjusted mean	SE	Adjusted mean	SE	Adjusted mean	SE	Adjusted mean	SE
Mental symptoms	1995	0.488	0.017	0.485	0.016	0.509	0.020	0.640	0.020 ^{***,a,c}
	1996	0.454	0.017	0.421	0.016	0.437	0.020	0.570	0.018 ^{***,a,c}
	1997	0.483	0.021	0.454	0.018	0.430	0.020	0.598	0.018 ^{***,a,c}
Physical symptoms	1995	1.716	0.025	1.930	0.023 ^{***}	2.213	0.030 ^{***,a}	2.669	0.030 ^{***,a,c}
	1996	1.657	0.026	1.805	0.024 ^{***}	2.156	0.030 ^{***,a}	2.570	0.027 ^{***,a,c}
	1997	1.715	0.032	1.831	0.027 [*]	2.109	0.031 ^{***,a}	2.606	0.027 ^{***,a,c}
Sleep related symptoms	1995	0.230	0.010	0.264	0.009 [*]	0.278	0.011 ^{**}	0.337	0.011 ^{***,a,c}
	1996	0.245	0.010	0.241	0.009	0.269	0.012	0.316	0.010 ^{***,a,b}
	1997	0.230	0.012	0.257	0.010	0.255	0.011	0.315	0.010 ^{***,a,c}

SE: standard error.

ANCOVA was conducted to estimate the adjusted mean of symptom score according to daily VDT using hours.

Age, sex, daily working hours, monthly holidays, daily sleeping hours, and glasses or contact lens use were adjusted.

Significant difference of adjusted mean of symptom score compared with the group of <1 hr (* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$).Significant difference of adjusted mean of symptom score compared with the group of 1–3 hr (^a $P < 0.001$).Significant difference of adjusted mean of symptom score compared with the group of 3–5 hr (^b $P < 0.05$, ^c $P < 0.001$).

In most studies, the sample size was less than one thousand. In addition, most studies ignored confounding factors [Bergqvist, 1984; Gerr et al., 1996]. This prompted us to conduct a survey on a large group of over 25,000 workers considering various confounding factors such as sex, age, daily working hours, monthly holidays, daily sleeping hours, and glasses or contact lens use, and to repeat the same survey three times over three years to further confirm the results.

With regard to physical symptoms, Rossignol et al. [1987] reported a relationship between duration of daily VDT use and eyestrain or musculoskeletal symptoms without considering confounding factors in their cross-sectional study of 1,545 clerical workers. Polanyi et al. [1997] conducted a cross-sectional study of 1,007 newspaper employees to investigate the relationships between work-related musculoskeletal disorders (WMSDs) and work related factors such as sex, deadlines, screen position, psychological demands, social support, skill discretion, and duration of daily VDT use by multiple logistic regression analysis, and concluded that the odds ratio of WMSDs was significantly higher for five hours of daily VDT use compared with one and a half hours of daily VDT use. On the other hand, Shima et al. [1993] evaluated the effects of sex, age, days of weekly VDT use, hours of daily VDT use, and years of VDT use for visual and musculoskeletal symptoms in their cross-sectional study of 240 clerical workers, and found no significant differences with respect to hours of daily VDT use. Some studies [Knaue et al., 1985; Shimai et al., 1986] also failed to find any relationship.

In our study, we found a significant relationship between duration of daily VDT use and physical symptoms score after

adjusting for confounding factors. That is, the physical symptoms score became higher with increasing duration of daily VDT use with no threshold effect. Moreover, the same results were obtained consistently over a 3-year period.

In contrast to physical symptoms, few studies have investigated associations between VDT use and mental symptoms and sleep related symptoms. Tarumi et al. [1990] reported that psychological symptoms were less common than musculoskeletal symptoms in a cross-sectional study of 147 workers. Tachibana et al. [1998] performed a cross-sectional study of 271 workers and found that the odds ratios of disorders of initiating sleep, frequent sleep interruption, and early morning waking were significantly higher in VDT workers than non-VDT workers. Lindstrom investigated the relationships between VDT use and job demands, job characteristics or psychic well-being among 1,124 clerical workers, and observed relationships between extensive VDT use and psychological symptoms or fatigue in their cross-sectional study [Lindstrom, 1991]. However, these studies neither evaluated mental symptoms with respect to the amount of VDT use nor considered confounding factors.

In our study, the mental symptoms score and sleep related symptoms score were significantly higher in the group having more than 5 hr of daily VDT use than other groups after adjusting for confounding factors. This result suggested that the effect of duration of daily VDT use on these scores has a threshold effect, and the prevention of mental disorder and sleep disorder requires the restriction of VDT use to less than 5 hr per day.

In our study, the prevalence of absence of symptoms was high and Cronbach's alpha of physical symptoms and sleep

related symptoms were not high enough. In addition, as our study had a very large sample number, there is the possibility of overestimation. These are the limitations of our study, and support our contention that further study is needed.

However, the workers examined performed different types of work in their office even if most of them were clerical workers, and most of them used VDT as a part of their work. The types and sizes of VDT are different in each office, as is the work environment. It should be emphasized that even under such working conditions, our results were extremely consistent over a 3-year period.

In conclusion, our results suggest that physical symptoms increases with duration of daily VDT use without threshold, while mental and sleep related symptoms increase with VDT work of more than five hours per day.

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