

Computer use, neck and upper-extremity symptoms, eyestrain and headache among female and male upper secondary school students

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Objectives Computer use, neck and upper-extremity symptoms, headache, and eyestrain were studied in upper secondary school students.

Methods A questionnaire was completed by 1575 female and 1251 male students. Associations between computer use and health problems were analyzed by calculating the prevalence ratios for the health variables, considering computer use for >14–56 or >56 hours/week as compared with ≤14 hours/week (reference). Health problems were defined as aches or pain or other trouble at least three days in the preceding month.

Results Computer use (median) was reported to be 31 hours/week by the male students and 19 hours/week by the females. Most computer use (about 90%) took place outside school (eg, for entertainment). Headache was reported by 51% and 24%, and neck or shoulder symptoms by 31% and 15%, of the females and males, respectively. More than 50% of the females with health complaints indicated that their problems had disturbed their sleep, and they used painkillers to handle them. Between 10% and 43% experienced their health complaints as being related to computer use. For those using computers >56 hours/week, the prevalence ratios were significantly increased for neck or shoulder symptoms among both the females and the males, and for eyestrain and forearm symptoms among the females. Exposure–response relationships were indicated for the aforementioned associations. Approximately two-thirds of the students reported that they had not received any information in school about appropriate workplace layout and techniques for computer work.

Conclusions Despite their young age, the students were not protected from computer-related health complaints. Therefore, providing adolescents with information about proper computer ergonomics may help prevent such health problems.

Key terms adolescence; education; ergonomics; forearm; information; musculoskeletal symptom; shoulder; upper arm; visual display unit.

Students in upper secondary schools in Sweden are between 16 and 18 years of age. At that age, extensive computer use is a natural part of their everyday life, and it involves activities such as doing schoolwork, playing games, and accessing the Internet. Almost all students in upper secondary schools in Sweden today have access to computers both at school and at home (1).

Several studies have examined different health effects of computer use on adults, and symptoms in the upper extremities, headache, and eyestrain have been reported (2–6). Investigations have also indicated that prolonged computer use without breaks is associated with upper-extremity symptoms (7). Furthermore, it has been noted that factors such as poor workstation design, which

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might lead to postural strain (eg, static and nonneutral wrist, arm, or neck postures), are related to musculoskeletal symptoms in adult computer workers (3). Although most of the observed increases in relative risks for health complaints are moderate, the use of computers is widespread and may therefore have important implications for public health.

Somatic health complaints, such as headache and musculoskeletal symptoms, are common in adolescents in general (8–11). However, despite the widespread use of computers in that age group (eg, by students), only a few investigations have explored the health effects of computer use among young people. Associations with computer use have been reported mainly for headache and neck or shoulder symptoms (12–15). To our knowledge, no large population studies of adolescents have considered eyestrain or symptoms in the distal portions of the upper extremities, which represent areas of the body that are often found to exhibit problems in adults using computers. In a pilot study (16), our research group compared students from an upper secondary school with adult professional computer workers. The students used computers extensively, even more so than the professionals. Even though the students were much younger and had accumulated less computer-use time, the prevalence of findings and diagnoses were similar in the two groups.

The main objective of our study was to investigate computer use and health complaints among upper

secondary school students. More specific aims were (i) to study computer use in and outside of school, (ii) to determine the prevalence of headache, eyestrain, and neck and upper-extremity symptoms, (iii) to ascertain whether the health complaints were experienced as being related to computer use, (iv) to examine the consequences and strategies used to handle the symptoms, (v) to elucidate associations between health problems and the total duration of computer use, and (vi) to determine whether students receive information in school about appropriate workplace layout and techniques for computer work.

Study population and methods

Study population

In the fall semester of 2005, a questionnaire was distributed to the students attending 183 second-form classes in 38 upper secondary schools in Stockholm and three surrounding counties (Mälardalen). The sampling was done in two steps, as illustrated in figure 1. In the first step, 40 upper secondary schools were randomly selected among all those eligible. To be eligible, a school could not be undergoing any major reorganization or reconstruction, and it was to have ongoing upper secondary classes at the time of the study. In the second step, 183 classes were randomly chosen from the 40 schools

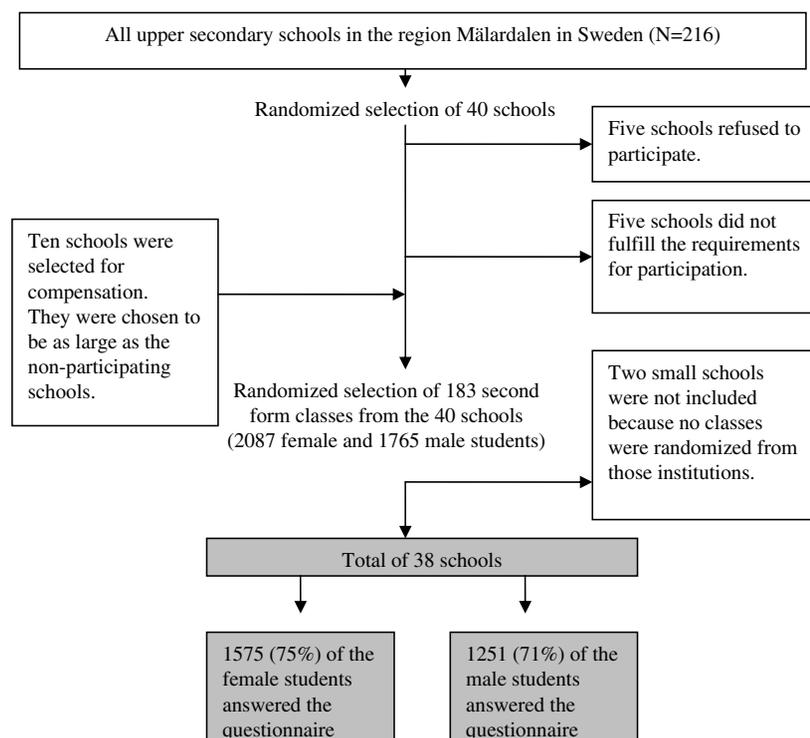


Figure 1. Flow chart of the selection procedure.

in the sample. All of the students in the selected classes were asked to fill out a questionnaire during school hours. A total of 1575 female students (representing 75% of all females in the classes) and 1251 male students (71% of all males in the classes) completed the questionnaire. The characteristics of the students are presented in table 1. Absent students represented the majority of the nonrespondents. The bulk of the students were between 16 and 18 years old, and their average body mass index was 21.6 (SD 4.2) kg/m².

Questionnaire

The questionnaire included items about computer use and the number of days with a headache, eyestrain, pain, or other aches or symptoms in different parts of the upper body during the previous month. The responses regarding the number of days with symptoms were given on a 6-point ordinal scale ranging from “never” to “all the time” during the previous month. A manikin was used to illustrate the regions of the body (figure 2). The students who reported health problems were also asked to indicate whether they felt that their symptoms were related to their computer use by choosing between the response alternatives “yes”, “no”, and “no idea”. There were also questions about the consequences of their health complaints and strategies to handle the problems. The students estimated their average computer use (hours and minutes) in six different parts: (i) weekly use of a desktop computer at school; (ii) weekly use of a laptop computer at school; daily computer use at home for schoolwork (iii) on weekdays and (iv) on weekends;

(v) daily computer use for recreation (playing games, chatting) on weekdays and (vi) on weekends. To calculate the total computer-use time per week, we added all of the time-weighted parts (weekly at school, daily

Table 1. Characteristics of the study group.

Characteristic	Female students (N=1575)		Male students (N=1251)	
	N	%	N	%
Type of educational program				
Theoretical	1011	64	828	66
Practical	550	35	415	33
Individual	14	1	8	1
Type of computer used at home				
Desktop	767	49	581	47
Laptop	55	3	30	2
Both laptop and desktop	719	46	612	49
No computer at home	28	2	19	2
Performed ≥30 minutes of at least moderate physical activity everyday or ≥30 minutes of strenuous activity at least three times a week				
Yes	470	31	531	46
No	1026	69	623	54
Watching TV or playing console games on weekdays (hours/day)				
<1	482	31	434	35
1–4	968	62	707	58
>4	110	7	87	7
Total hours of sleep on weekdays				
<6	132	9	139	12
6–8	857	55	683	57
>8	563	36	383	32
Feeling of getting enough sleep				
Yes	599	38	534	44
No	954	62	679	56

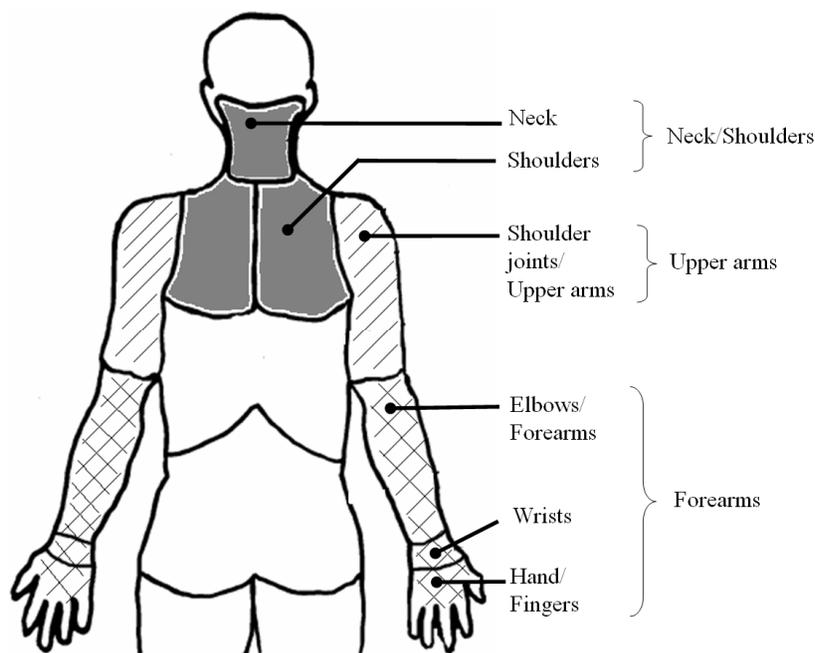


Figure 2. Designation of the three regions exhibiting symptoms: neck or shoulders, upper arms, and forearms.

on weekdays \times 5, and daily on weekends \times 2) together. The questionnaire also included one item concerning whether information or education was given in school regarding good workplace design and techniques for computer work.

The protocol was sent to the Ethics Committee of the Karolinska Institutet, but approval of the protocol was deemed unnecessary.

Data treatment and analysis

All of the analyses were done separately for the female and male students. The cases were defined as adolescents who experienced headache, eyestrain, pain, or other aches or symptoms in the neck and upper extremities (divided into neck or shoulders, upper arms, and forearms) for 3 days or more during the preceding month (figure 2). Prevalence ratios and 95% confidence intervals were calculated for the outcome variables for two different exposure categories versus a reference category consisting of students using computers for a total of ≤ 14 hours a week. The exposed groups consisted of those using computers for >14 – 56 hours/week (moderate exposure) or >56 hours/week (high exposure). All of

the analyses were performed using SPSS 14.00 (SPSS Inc, Chicago, IL, USA).

Results

Computer use

Almost all of the students (99% of both genders) had used computers during the preceding month. Most (about 90%) of the time spent at computers occurred outside of school. The male students used computers more than the female students did, with a median of 28 hours/week outside school and 3 hours/week in school (excluding students not using computers). The corresponding figures for the female students were 17 and 2 hours/week, respectively (table 2).

Unreasonable extensive computer use, for example, >168 hours/week, was reported by 1% of the female students and 2% of the male students (figure 3).

There was a larger proportion of male than female students who used computers for 3 hours or more without breaks at least twice a week, 21% males and 9% females (table 3).

Table 2. Time spent using computers (hours/week) by the female and male students (N = those affirming use, Q1 = first quartile, Q3 = third quartile)

Computer use	Female students (N=1575)					Male students (N=1251)				
	N	Median	Q1–Q3	Mean	SD	N	Median	Q1–Q3	Mean	SD
Computer used in school	1273	2	1–4	3	4	1070	3	1–5	5	8
Computer used outside school for schoolwork	1320	6	3–12	9	13	896	5	3–10	9	14
Computer used outside school for chatting, playing games, etc	1444	10	5–20	17	35	1138	23	12–38	32	47
Total computer use outside school	1474	17	9–29	25	39	1151	28	16–45	39	52
Total computer use	1443	19	11–32	27	40	1146	31	18–50	42	54

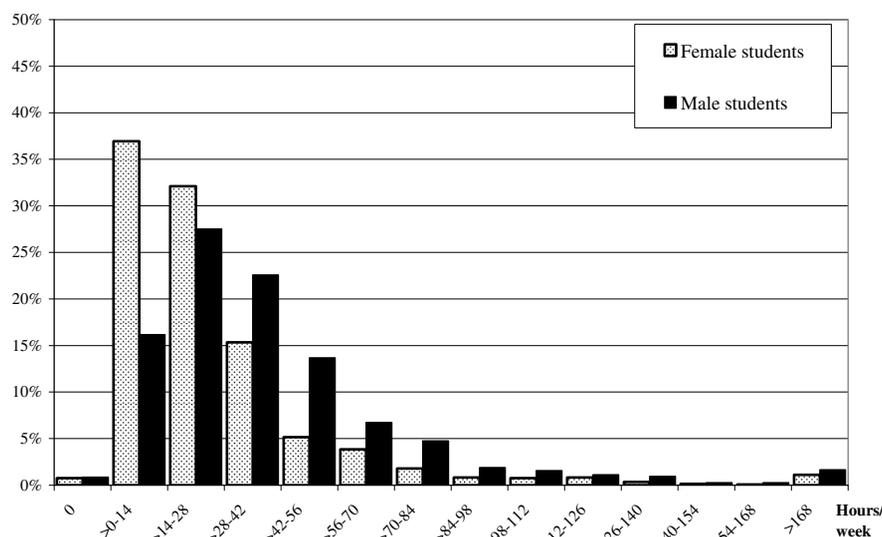


Figure 3. Distribution of total time (hours/week) reported for computer use by the female (N=1554) and male (N=1156) students. (N = number of students who answered all the questions considering computer use)

Table 3. Maximum duration and frequency of computer use without at least a 10-minute break among the female and male students.

Frequency of computer use	Female students (N=1575)		Male students (N=1251)	
	N	%	N	%
	<1 hour or ≥1 hour less than twice a week	932	60	556
1–2 hours at least twice a week	355	23	260	21
2–3 hours at least twice a week	137	9	159	13
3–4 hours at least twice a week	75	5	98	8
>4 hours at least twice a week	66	4	165	13

Table 4. Prevalence of health complaints lasting at least 3 days during the preceding month (cases) reported by the female and male students.

Health complaint	Female students (N=1575)			Male students (N=1251)		
	Respon- dents (N)	Cases (N)	%	Respon- dents (N)	Cases (N)	%
	Headache	1548	783	51	1202	284
Eyestrain	1548	326	21	1202	141	12
Neck	1561	487	31	1224	181	15
Shoulders	1561	293	19	1224	98	8
Neck or shoulders	1561	579	37	1224	220	18
Upper arms	1561	208	13	1224	117	10
Elbows or forearms	1561	74	5	1224	69	6
Wrists	1561	155	10	1224	121	10
Hand or fingers	1561	108	7	1224	83	7
Forearms	1561	239	15	1224	182	15
Any symptoms in the neck or upper extremities	1561	689	44	1224	347	28

Prevalence of symptoms experienced in general and in relation to computer use

In general, a larger proportion of the female than the male students reported having health problems for 3 days or more during the preceding month (table 4). The symptoms mentioned most often by both female and male students were headache followed by neck or shoulder ailments. Between 10–43% of the students who had health complaints believed that their symptoms were related to computer use (depending on the type of health complaints) (table 5).

Consequences of, and strategies for, handling health problems

About half of the students who reported headache, eyestrain, or neck or upper-extremity symptoms indicated that their sleep was disturbed by their health problems

Table 5. Answers to the question “Do you believe your health complaint is related to your computer use?” given by the cases indicated in table 4.

Health complaint	Female students		Male students	
	N	%	N	%
Headache^a				
No	467	63	135	54
Yes	72	10	47	19
No idea	202	27	67	27
Eyestrain^b				
No	141	47	45	38
Yes	81	27	51	43
No idea	81	27	24	20
Neck or shoulders^c				
No	239	44	93	47
Yes	197	36	63	32
No idea	113	21	41	21
Upper arms^d				
No	102	52	67	67
Yes	56	29	23	23
No idea	37	19	10	10
Forearms^e				
No	116	52	89	57
Yes	79	35	51	32
No idea	30	13	17	11

^a Total number of cases = 783 for the female students and 284 for the male students.

^b Total number of cases = 326 for the female students and 141 for the male students.

^c Total number of cases = 579 for the female students and 220 for the male students.

^d Total number of cases = 208 for the female students and 117 for the male students.

^e Total number of cases = 239 for the female students and 182 for the male students.

Table 6. Consequences of, and strategies for, handling health problems among the cases. (N = number of students with one or more health complaints)

Health problem	Female students (N=1050)		Male students (N=541)	
	Respondents to the question (N)	%	Respondents to the question (N)	%
Sleep disturbances	974	54	489	44
Contact with school health services, physician or physiotherapist	986	21	497	13
Use of medication (eg, painkillers)	996	60	494	34
Change in computer workstation	979	8.2	495	12

(table 6). Sixty percent of the female students with health complaints reported that they had used some kind of medication (eg, painkillers) during the previous month. Furthermore, about 10% had modified their computer workplace layout as a consequence of their symptoms.

Information in school about appropriate workplace layout and techniques for computer work

Sixty-three percent of the students reported that they had not received any information or education in school regarding appropriate workplace layout and techniques for computer work (table 7).

Symptoms associated with computer use

Significantly increased prevalence ratios were observed in the highest exposure category (>56 hours/week) for neck or shoulder symptoms among both the female and male students, and for eyestrain and forearm symptoms among the female students (table 8). Exposure-response relationships were also indicated for the aforementioned associations.

Discussion

This study strengthens previous findings showing that headache and musculoskeletal symptoms are common in general among Swedish adolescents, especially among females (10). The study also confirms the results from

Table 7. Responses to the question concerning whether the students had received information or education in school about appropriate workplace layout and techniques for computer work (number of students who answered the question = 2784).

Response	%
No	63
Yes, some, but I need much more information	4
Yes, but I need some more information	7
Yes, I have received enough information	20
I don't know	5

other studies that adolescents are frequent computer users and young males often use computers more and for longer periods than females (1, 17). Computers were predominately used for playing games and chatting outside school hours (eg, for entertainment). However, the cross-sectional design of our study and the fact that no confounding analyses were done prevent us from drawing any conclusions about the causes of the health complaints reported by the investigated adolescents. Nonetheless, the students own beliefs that their health complaints were computer related, earlier observations concerning the same age group, and knowledge gained in longitudinal studies of adult computer users can help us to understand whether computer use may contribute to the development of health complaints, even in adolescence.

Both in a pilot study conducted by our research group on upper secondary school students with intensive use of laptop computers and in a study of adult professional computer operators, similar questionnaires and definitions of health complaints were used as in our present investigation (ie, health complaints for ≥ 3 days during the preceding month). This information enables us to make some comparisons. The prevalence of health complaints in the present investigation was lower in general, both compared with the complaints of the students with intensive use of laptop computers and those of adult professional computer operators. For example, the prevalence of neck complaints among the females was 31% in our present study and 49% in the study of a group of students with intensive use of laptop computers and 46% in the study on a group of adult computer operators. The corresponding prevalences for males were 15%, 25%, and 24%, respectively. The higher prevalences of health complaints in the group of adult computer operators might be expected due to its higher mean age. However, the higher prevalence of

Table 8. Prevalence ratios (PR) and 95% confidence intervals (95% CI) for headache, eyestrain, and symptoms in different regions of the neck and upper extremities among the students, divided into three computer use groups.

Health complaint	Computer use (hours/week)	Female students				Male students			
		Cases (N)	Noncases (N)	PR	95% CI	Cases (N)	Noncases (N)	PR	95% CI
Headache	≤ 14	261	280	1.00	..	34	158	1.00	..
	>14-56	391	364	1.07	0.96-1.20	186	526	1.47	1.06-2.05
	>56	79	60	1.18	1.00-1.40	49	167	1.28	0.87-1.90
Eyestrain	≤ 14	92	449	1.00	..	21	171	1.00	..
	>14-56	166	589	1.29	1.03-1.63	83	629	1.07	0.68-1.67
	>56	43	96	1.82	1.33-2.48	30	186	1.27	0.75-2.14
Neck or shoulders	≤ 14	191	353	1.00	..	26	166	1.00	..
	>14-56	290	472	1.08	0.94-1.25	130	600	1.32	0.89-1.94
	>56	66	75	1.33	1.08-1.64	47	171	1.59	1.03-2.47
Upper arms	≤ 14	61	483	1.00	..	16	176	1.00	..
	>14-56	11	651	1.30	0.97-1.74	60	670	0.99	0.58-1.67
	>56	20	121	1.26	0.79-2.02	30	188	1.65	0.93-2.93
Forearms	≤ 14	61	483	1.00	..	25	167	1.00	..
	>14-56	133	629	1.56	1.17-2.06	101	629	1.06	0.71-1.60
	>56	30	111	1.90	1.28-2.82	44	174	1.55	0.99-2.43

health complaints among students of the same age, with intensive use of laptop computers, may indicate that the intensive use of laptop computers can be one contributing factor to their health complaints.

According to our results, the only health complaint that was more common in our student group than in the group of adult computer operators presented in the earlier study was headache among the females (51% versus 43%). High prevalences of headache in young females have also been observed in other studies. In general, muscular factors can play an important role in the development of headache (18, 19). One hypothesis about how headache can be related to computer use is that a computer display that is placed too high or too low can increase the load on neck muscles (20). However, there was no clear association between extensive computer use and headache among the female students in our study. This finding indicates that computer use only could not explain the high prevalence of headache among females in our study. One possible explanation for this finding is that the prevalence of headache among young girls increases when they reach ages of puberty and the onset of menstruation (21). The high background prevalence of headache among the female students in the reference group may explain why no association could be observed. For the male students, the prevalence ratios for headache were significantly increased in the moderate-exposure group but were somewhat lower, and not significant, in the group with the highest exposure. To our knowledge, so far only one large population study has analyzed relationships between computer use and headache among adolescents (14). Alexander & Currie (14) found that headache was more common in a group of young people (aged 11–15 years) who used computers at least once a week than among those who were at computers once a month or less. Similar results were observed by Oksanen et al (15) in a smaller group of 13-year-old school children. Alexander & Currie observed that the differences in the prevalence of headache between the frequent and less frequent users were particularly pronounced among younger boys and girls (11 years of age). Among older girls, a relatively high prevalence of headache was observed for both frequent and less frequent computer users. That finding concurs with our results showing that a high prevalence of headache among female students in the reference group can hide possible associations between computer use and headache.

Our results strengthen previous findings indicating that neck or shoulder symptoms are associated with computer use among adolescents (12, 14). Nevertheless, the relationships that were detected were weak, and significantly increased prevalences of neck or shoulder symptoms were found only for extensive computer use of >56 hours/week (8 hours/day). Hakala et al (12) observed that reported computer use of >2 hours daily

was a threshold for a significantly increased odds ratio for weekly neck and shoulder pain during the last half year. This threshold could not be confirmed by us in our present study. The difference in thresholds between the cited study and the current investigation may be partly explained by a possible overestimation of the duration of computer use in our study and the fact that different procedures were employed to measure computer time. In another study, Diepenmaat et al (13) studied a population of Dutch adolescents and did not observe any significant associations between computer use and neck or shoulder symptoms. Diepenmaat and her colleagues measured use in a way similar to the method applied by us in our present investigation, but in their study the group with the highest exposure used computers for >3 hours/day, as compared with more than 8 hours/day in our investigation. When computer use is measured in this way, the level of 3 hours/day of computer use is possibly too low for an increased risk of neck or shoulder symptoms to be identified. If there is a critical threshold, it is possibly somewhere in between the level observed by Hakala et al and our observations.

Compared with the proportion of male students, a larger proportion of the females reported symptoms, and computer-related symptoms particularly in the neck or shoulder area. This difference may have been at least partly due to constitutional and physiological factors. For instance, since females are generally smaller and have narrower shoulders than males, normal keyboards are often too wide for them, and they are forced to move their shoulders to an outwardly rotated or abducted position when controlling the mouse (7). Moreover, both subjective and objective measurement methods have indicated greater sensitivity to pain for women than for men (22). In addition, exposure may differ, for example, because males tend to use computers more for surfing and playing games, and females are more often at computers for the purpose of communication (23). An obvious disparity is that the input devices for games can be keyboard, mouse, and joystick, whereas a keyboard and a mouse are normally used for communication.

Exposure–response relationships between total hours of computer use and both eyestrain and forearm symptoms were indicated for the female participants in our investigation. To our knowledge, no other large population study has examined such relationships and computer use among adolescents. Research has revealed that proper lighting, correct positioning of the monitor, and frequent breaks from computer use may prevent computer-related eyestrain (4, 24). In addition, mouse use has been shown to be the most prominent risk factor for forearm symptoms among adult computer operators (25). To prevent such problems, it is recommended that computer users avoid “doubleclicking”, take frequent breaks, and vary the type of input devices they use (26).

About 10–40% of all students who reported health complaints experienced their problems as being associated with their use of computers (depending on the type of health complaint). In general, this group corresponds to less than 5% of all the students, except when the females with neck or shoulder symptoms (who indicated that 13% of their symptoms were related to computer use) are considered. No similar data on students have been published. However, the indicated findings are comparable with data from studies of the working population in Sweden (27), which showed that about 4.2% of the women and 2.1% of the men reported that they had had health problems connected with computer use during the past year. This finding indicates that about the same proportion of adolescents and adults experience computer-related health problems.

To estimate the severity of the health complaints, we also asked the students about the consequences of their symptoms and the strategies they used to handle their problems. A large proportion of the students who had symptoms reported that the manifestations affected their sleep, which has also been observed for children and adolescents in other studies (8, 16). Sufficient sleep is important for the recovery of both mental and physical functions, and hence it is notable that the students in our investigation had symptoms that were severe enough to affect their sleep. A high consumption of painkillers was also reported, particularly by the female students, and that finding is in line with earlier observations on Swedish school adolescents (16, 28).

Several limitations of this study must be taken into account. One disadvantage is the fact that both the exposure variables and outcome variables were self-reported. Faucett & Rempel (29) investigated a population of newspaper workers and concluded that self-reporting tended to overestimate computer use, especially among young employees. Similarly, some of the students in our study reported unreasonably extensive computer use; for example, their answers to questions about sleeping habits indicated that they had spent more time per day at computers than the number of hours they had been awake. Systematic overestimation is a plausible explanation for that observation, because we added together the results of several of the six open questions concerning duration of computer use, which might have given an unreasonable total sum. Consequently, the estimate of the total number of hours of computer use per week reported by the students should be interpreted with caution. Notwithstanding, according to Faucett & Rempel, the overestimation of exposure in their investigation was not associated with the perception of musculoskeletal symptoms. If the same applies to our study, the threshold of 56 hours/week of computer use for an increased prevalence of neck or shoulder symptoms would be lowered, whereas the associations between computer use

and symptoms would persist. When all of the students who reported more hours of computer use than waking hours on weekdays and holidays were excluded from the dataset, the median computer use was only changed from 18.6 to 18.2 hours/week for the females and from 30.8 to 29.8 hours/week for the males.

Factors such as poor workstation design have been reported to be related to musculoskeletal symptoms among adult computer workers (3). Simple measures can often improve a poorly arranged workplace, and appropriate operational techniques have been shown to decrease the muscular load associated with computer use (30, 31). Even if there is not yet any strong scientific evidence of the efficiency of interventions aimed at preventing musculoskeletal and visual symptoms among computer operators (32), it is reasonable to implement a preventive approach. Indeed, if students are given knowledge of adequate practical techniques and actions that can be done at home or in school, there is probably a potential for prevention. Therefore, it is notable that most of the students who answered our questionnaire reported that they had not received any information in school about suitable workplace layout and techniques for computer work.

In conclusion, the fact that adolescents are young does not protect them from possible computer-related health complaints. Furthermore, such health problems are especially detrimental if they prevent young students from using computers. Most professions today involve the use of computers, and the same will probably be true in the future. Accordingly, any ailments associated with the use of computers would clearly restrict possibilities in future worklife. Giving adolescents information about ergonomically correct computer use offers the potential of preventing health problems. In that context, special attention should be directed towards computer activities outside school, which constitute the greater part of the use. Furthermore, research should be focused on the possible vulnerability of females because, despite less exposure, they more often report health problems, which also seem to be more serious in nature. Prospective studies should be launched to follow people from a young age, when they are still unexposed, through the early school years, and far into worklife. The objective should be to identify and elucidate possible predictors of good and bad health in relation to computer use. Objective measurements of computer use should preferably be used to prevent recall estimation errors.

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