European Journal of Public Health, Vol. 16, No. 5, 536–541

doi:10.1093/eurpub/ckl025 Advance Access published on March 8, 2006

Adolescent health

Frequent computer-related activities increase the risk of neck–shoulder and low back pain in adolescents

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Background: Neck–shoulder pain (NSP) and low back pain (LBP) increased among adolescents in the 1990s and the beginning of 2000. A potential risk factor for this increase is the use of information and communication technology. We studied how the use of computers, the Internet, and mobile phones, playing digital games and viewing television are related to NSP and LBP in adolescents. **Methods:** Mailed survey with nationally representative samples of 14-, 16-, and 18-year-old Finns in 2003 ($n = 6003$, response rate 68%). The outcome variables were weekly NSP and LBP. **Results:** NSP was perceived by 26% and LBP by 12%. When compared with non-users, the risk of NSP was 1.3 (adjusted odds ratios) when using computers >2–3 h/day, and 1.8 when using 4–5 h/day; 2.5 when using computers ≥42 h/week, and 1.7 when using the Internet ≥42 h/week. Compared with non-users, the risk of LBP was 2.0 when using computers >5 h/day, 1.7 when using ≥42 h/week, 1.8 when using the Internet ≥42 h/week, and 2.0 when playing digital games >5 h/day. Times spent on digital gaming, viewing television, and using mobile phones were not associated with NSP, nor were use of mobile phones and viewing television with LBP after adjusting for confounding factors. **Conclusions:** Frequent computer-related activities are an independent risk factor for NSP and LBP. Daily use of computers exceeding 2–3 h seems to be a threshold for NSP and exceeding 5 h for LBP. Computer-related activities may explain the increase of NSP and LBP in the 1990s and the beginning of 2000.

Keywords: adolescence, computer, digital games, Internet, low back pain, mobile phone, neck–shoulder pain

Low back pain (LBP) and neck pain (NP) are significant health problems not only in adults but also in the young. In studies exploring populations of 300 children or more,[1] the lifetime prevalence of LBP has ranged from 30% to 51%. NP has emerged as one of the most common pain symptoms and the most persistent musculoskeletal pain symptom.[2,3] In adolescence, 15–30% suffer from weekly NP and 1–15% from weekly LBP.[4–6] Co-morbidity of the symptoms has been reported.[5]

Based on Finnish large-scale population surveys Hakala *et al.*[6] showed that neck–shoulder pain (NSP) and LBP increased among adolescents in the 1990s and the beginning of 2000. Comparing findings from two surveys within several countries, the WHO cross-national survey showed that in 1993–1994 every fifth 11- to 15-year-old reported weekly backache[7] and by 1997–1998 the figure had risen to every third.[8] To assess causes behind this development, we need to explore emergence of new risk factors as well as changes in the prevalence of those previously known.

Female gender, age, history of spinal trauma, parental history of LBP, disc degeneration, increased height and sitting height, high level of physical activity, television viewing, smoking, depression, and stress increase the risk of non-specific LBP.[1] Of these risk factors television viewing among 10- to 14-year-olds has increased in the 1990s,[9] yet some studies have reported no association between LBP and time spent on viewing television.[10] Although little studied, NP in children has been associated with early timing of puberty, high intensity of physical exercise, smoking,[5] female gender, stress, and depressive symptoms.[5,11] It is unlikely that changes in the known risk factors could explain the increase in NP and LBP.

A major change in the 1990s and the beginning of 2000 was the explosion in the use of information and communication technology (ICT). In the beginning of the 1980s computer use by adolescents was negligible but the use increased steeply: the average daily use among 10- to 14-year-olds was 11 min in 1987–1988 and 47 min in 1999–2000.[9] At present, most adolescents use computers regularly for surfing in the Internet, playing games, writing or keeping contacts via e-mail. Further, two other forms of ICT, playing digital games on play consoles and use of mobile phones, have tremendously increased. As an activity, playing console games and using computer resemble each other; sitting work in static posture with repetitive upper extremity movements. Mobile phones are used not only for phoning but also for playing games and sending text messages, the latter activities have similarities to computer use.

Studies on adult work life support a hypothesis that computer-related activities can cause NP and LBP in the young.[12] Neck symptoms have been associated with low or high screen position, shoulder symptoms with high screen position and shoulder elevation in computer mouse users,[13] and the risk of NP with poor placement of keyboard.[14] Use of keyboard for ≥4 h during a working day has been associated with shoulder, wrist, or hand pain but not with NP.[15] Further, work exceeding 15 h/week at visual display units presented as a risk factor for NSP.[16] An obvious reduction in musculoskeletal

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Table 1 Prevalence rate (%) of NSP and LBP, and use of ICT by sex and age, in 2003

Frequency	Boys (age)			Girls (age)			All[a]
	14	16	18	14	16	18	
NSP							
Almost daily	3	5	6	9	16	20	10
About once a week	8	12	14	14	22	25	16
About once a month	28	30	29	30	32	32	30
Seldom/not at all	61	53	51	47	30	23	44
Total	100	100	100	100	100	100	100
LBP							
Almost daily	1	4	5	2	5	5	4
About once a week	5	8	11	5	8	13	8
About once a month	15	19	20	24	36	34	25
Seldom/not at all	79	69	64	69	51	48	63
Total	100	100	100	100	100	100	100
Weekly use of computer							
Not at all	5	4	6	10	10	13	8
1–13 h	67	62	66	83	83	80	74
14–41 h	26	30	23	7	6	6	16
≥42 h	2	4	5	0.4	1	1	2
Total	100	100	100	100	100	100	100
Weekly use of the Internet							
Not at all	14	11	11	14	13	14	13
1–13 h	75	72	74	80	82	82	77
14–41 h	10	14	12	5	4	3	8
≥42 h	1	3	3	1	1	1	2
Total	100	100	100	100	100	100	100
Daily use of computer							
Not at all or not daily	70	58	56	68	66	70	65
≤1 h	23	28	27	24	25	23	25
2–3 h	5	10	11	6.9	7	5	7
4–5 h	1	2	3	1	1	1	2
>5 h	1	2	3	0.1	1	1	1
Total	100	100	100	100	100	100	100
Daily playing digital games							
Not at all or not daily	29	35	57	82	87	92	65
≤1 h	29	26	20	13	9	6	17
2–3 h	32	27	17	4	3	1	13
4–5 h	7	7	3	0.6	0.6	0.6	3
>5 h	3	5	3	0.2	0.2	0.3	2
Total	100	100	100	100	100	100	100
Daily use of mobile phones for phoning, playing games, text messages							
Not at all or not daily	44	38	32	30	21	20	31
≤1 h	49	55	62	57	64	67	59
2–3 h	5	5	5	9	11	10	8
4–5 h	1	1	1	2	2	1	1
>5 h	1	1	0	2	2	2	1
Total	100	100	100	100	100	100	100
Daily viewing TV, video, or DVD							
Not at all or not daily	14	13	19	13	15	13	14
≤1 h	28	31	26	25	27	20	26
2–3 h	48	45	43	51	47	54	49
4–5 h	7	8	9	9	9	11	9
>5 h	3	3	3	2	2	2	2
Total	100	100	100	100	100	100	100

a: Age and sex adjusted

discomfort in the shoulder, neck, and upper back areas has been observed after instructed computer users' sitting posture and workstations.[17]

Of the few studies investigating the association of computer-related activities with back or neck pain in adolescents, most are cross-sectional with unrepresentative, small samples. A significant association was discovered between the number of hours spent on computer and overall musculoskeletal pain in a sample of 152 adolescents.[18] Computer use exceeding 15 h/week was a risk factor for LBP in a sample of 88 adolescents.[19] Furthermore, 212 students (age 5–18) experienced discomfort in the back (15%) attributable to computer use,[20] and 60% of 10- to 17-year-olds reported discomfort in the neck region during laptop computer use.[21] According to the results from a larger study (n = 4404) documented by Alexander and Currie,[22] time spent with computer was associated with neck/shoulder pain among 11-, 13-, and 15-year-olds. Specific computer activities such as using joystick or playing games were significantly predictive of physical discomfort.[20] Gunzburg *et al.*[10] discovered significantly more LBP in 9-year-old children who played video games >2 h/day. Some cross-sectional studies have indicated that the time spent on viewing television and video is positively related to back pain.[1,19,23] The association between mobile phones and back or neck pain has not been studied earlier.

Our study investigates how the use of computers, the Internet, and mobile phones, playing digital games and viewing television are related to NSP and LBP in a national survey of 14- to 18-year-olds. It was hypothesized that computer-related activities increase NSP and LBP in adolescents.

Methods

We used data from the Adolescent Health and Lifestyle Survey 2003, a nation-wide monitoring system of Finnish adolescents. Self-administered questionnaires were mailed to 14-, 16-, and 18-year-olds in February with two re-inquiries to non-respondents. Sample size was 8810, 6003 responded, and response rate was 68% (14-year-old girls: n = 1245, 78%; 14-year-old boys: n = 1092, 66%; 16-year-old girls: n = 1296, 79%; 16-year-old boys: n = 1003, 59%; 18-year-old girls: n = 797, 74%; 18-year-old boys: n = 570, 50%).

The sample was drawn from the Population Register Center by selecting all Finns born at certain adjacent dates in July.

In terms of NSP, respondents were asked: 'Have you had neck or shoulder pain during the past half a year?' with alternatives (i) seldom or not at all, (ii) about once a month, (iii) about once a week, and (iv) almost daily. In the analysis the target variable was dichotomized by joining categories (iii) and (iv) into 'at least weekly' and categories (i) and (ii) into contrast category. In terms of LBP, respondents were asked: 'Have you had low back pain during the past half a year?' Alternatives provided were the same.

Exposure time to ICT was measured by asking how many hours respondents spent daily on (i) viewing TV, videos, or DVD; (ii) playing digital games (computers, the Internet, TV, console games); (iii) using mobile phones for phoning, text messages, playing games; and (iv) using computer for e-mails, writing, and surfing. Alternatives were (i) not at all or not daily, (ii) daily $\leq$1 h, (iii) daily 2–3 h, (iv) daily 4–5 h, and (v) daily $>$5 h. Two open questions were used: 'How many hours on average do you use computer in a week?' and 'How many hours on average do you use the Internet in a week?' The answers were categorized into four groups as follows: (i) not at all, (ii) weekly 1–13 h (corresponding $<$2 h daily), (iii) weekly 14–41 h (corresponding 2–5.9 h daily), and (iv) weekly $\geq$42 h (corresponding $\geq$5 h daily). Several exposure variables were used in order to increase the internal validity.

Several confounding factors were controlled for in the analysis. *Parents' level of education* was divided into six groups as follows: (i) both parents have a primary/lower secondary education (up to 9–10 school years); (ii) one has an upper secondary (up to 12 school years), the other a primary/lower secondary education; (iii) one has a tertiary ($\sim$13–18 school years), the other a primary/lower secondary education; (iv) both have an upper secondary education; (v) one has an upper secondary, the other a tertiary education; and (vi) both have a tertiary education. If the education of one parent was unknown, the respondent was categorized according to the other parent's education into groups (i), (iv), or (vi). Classification was derived from the official education statistics in Finland.[24] *Adolescents' school success* was measured by two questions according to respondent's age: what kind of school respondent was attending to (relevant to 16- to 18-year-olds only), and what kind of grades respondent received last when compared to class average. Seven groups were formed as follows: (i) high school, better than average; (ii) high school, average/worse; (iii) other school, better than average; (iv) other school, average/worse; (v) not at school; (vi) 14 years, better than average; and (vii) 14 years, average/worse.

Timing of puberty was classified according to girl's age at menarche into three categories as follows: (i) $<$12 (early), (ii) 12–13 years (average), and (iii) $>$13 (late); and according to boy's age at first ejaculation into (i) $<$13 (early), (ii) at age 13 (average), and (iii) $>$13 (late). *Efficiency of physical activity* was measured by three questions: how often respondents participated in sports, how often in other physical activity in their free time, and whether they got out of breath and sweated when exercising. The answers were divided into following four groups: (i) no physical efficiency, (ii) physical activity with low efficiency, (iii) physical activity with high efficiency, and (iv) efficiency unknown.

An index of eight *stress symptoms* (stomach ache, feeling nervous/tension, irritability/temper tantrums, difficulties in falling asleep/waking up at night, headache, trembling of hands, feeling tired/weak, feeling dizzy) was categorized by counting the number of symptoms perceived at least weekly: no symptoms/one symptom/two to three symptoms/four or more symptoms.

Repeatability studies. A subsample of 14- to 16-year-olds (n = 800) was taken from the original subject series by systematic sampling, randomizing the first. An identical questionnaire was sent to those who answered the survey (n = 566) 4 weeks after receipt of their original questionnaire. Of these 447 (79%) returned the questionnaire. Test–retest reliability of weekly symptoms and six ICT variables were tested with kappa coefficient. Results were 0.56 for NSP, 0.56 for LBP, 0.45 for weekly use of computers, 0.65 for weekly use of the Internet, 0.45 for daily use of computers, 0.54 for playing digital games, 0.47 for mobile phones, and 0.47 for viewing television. These values represent a fair to good agreement beyond chance between the two questionnaires.

Analysis of non-respondents. The data were divided into three categories according to the return date of the questionnaire. It was assumed that the later the person answers (original questionnaire/first re-inquiry/second re-inquiry) the more he/she resembles a non-respondent. There were no systematic or statistically significant differences in categories of symptoms or ICT variables in the entire population, or by age and sex.

Statistical analysis. Data were analysed by using the SPSS for Windows, version 11.0. In the logistic regression analysis, weekly NSP and LBP were outcome variables, and the variables on ICT use were predictor variables. Removal limit for variables was 0.1. After examining the effect of each ICT variable, adjusted for age and sex (model 1), parents' level of education, adolescents' school success, timing of puberty, and efficiency of physical activity were included into the models (models 2 and 3). These variables were considered as potential confounders and treated as covariates, because they were significant independent variables in the models with age, sex, and ICT variable. In model 3, stress symptoms variable was added. Because NSP and LBP, like the other measured stress symptoms, can be a dimension of general ill-health (stress), we wanted to see whether the relationships of NSP and LBP with ICT use were independent of other stress symptoms. Variables were included or excluded from each model based on the likelihood ratio test at 95% confidence level (95% CI).

Results

NSP was perceived once a week or more frequently by 26%, and LBP by 12% of 14- to 18-year-olds (table 1). Prevalence of NSP and LBP was higher among girls than among boys, and it increased by age. Boys spent more time on using computers, the Internet, and gaming than girls. Girls spent more time on using mobile phones. Times of viewing TV, video, or DVD were equal in boys and girls (table 1).

Risk of NSP increased parallel to increase in the use of computers, the Internet, playing digital games and mobile phones, but not in viewing TV (table 2, model 1). A dose–response relationship was observed in the weekly and daily use of computers. In model 2, when parents' education level, school success, timing of puberty, and efficiency of physical activity were adjusted for, playing digital games was no longer related to NSP. Adding stress symptoms (model 3), the risk increased with the increasing exposure time in the computer and the Internet use, but the dose–response relationship disappeared in daily computer use. Computer use of $\geq$42 h weekly, or $>$2–3 h daily, and the Internet use of $\geq$14 h weekly presented a threshold for weekly NSP. Odds ratios increased with the increasing time of using computers and the Internet. Use of mobile phones was no longer significantly associated with NSP.

Risk of LBP was significantly higher when exposure time was $\geq$42 h/week and $>$5 h/day in computer use, $\geq$42 h/week in the Internet use, and $>$5 h/day in playing digital games (models 1–3, table 3). Statistically significant results were obtained in mobile phone use in one category (2–3 h/day), which, however, is an inconsistent result, and also in viewing television ($>$5 h/day) in models 1 and 2, but the latter disappeared in model 3.

Table 2 Risk (OR, 95% CI) for weekly NSP according to use of ICT among 14- to 18-year-old Finns. Separate models for each ICT variable

Exposure to ICT	Model 1[a]		Model 2[b]		Model 3[c]	
	OR	95% CI	OR	95% CI	OR	95% CI
Weekly use of computer						
Not at all	1.0[d]		1.0		1.0	
1–13 h	1.0	0.8–1.2	1.1	0.8–1.3	1.1	0.8–1.4
14–41 h	**1.3**	**1.0–1.7**	**1.3**	**1.0–1.8**	1.2	0.9–1.7
≥42 h	**2.3**	**1.5–3.6**	**2.4**	**1.4–4.0**	**2.5**	**1.5–4.3**
Weekly use of the Internet						
Not at all	1.0		1.0		1.0	
1–13 h	1.1	0.9–1.3	1.2	0.9–1.4	1.1	0.9–1.4
14–41 h	**1.7**	**1.3–2.2**	**1.7**	**1.2–2.3**	**1.4**	**1.0–2.0**
≥42 h	**1.6**	**1.0–2.7**	**1.7**	**1.0–3.0**	**1.7**	**1.0–3.1**
Daily use of computer						
Not at all or not daily	1.0		1.0		1.0	
≤1 h	1.1	0.9–1.2	1.1	0.9–1.2	1.0	0.8–1.3
2–3 h	**1.4**	**1.1–1.8**	**1.4**	**1.1–1.8**	**1.3**	**1.0–1.7**
4–5 h	**2.0**	**1.2–3.3**	**1.8**	**1.0–3.1**	**1.8**	**1.0–3.3**
>5 h	**2.5**	**1.4–4.5**	**2.1**	**1.1–4.3**	1.4	0.7–3.0
Daily playing digital games						
Not at all or not daily	1.0		1.0		1.0	
≤1 h	1.1	0.9–1.3	1.0	0.8–1.2	0.9	0.7–1.1
2–3 h	1.2	0.9–1.4	1.0	0.8–1.3	1.0	0.8–1.3
4–5 h	1.1	0.7–1.7	1.0	0.6–1.6	1.0	0.6–1.6
>5 h	**1.9**	**1.2–3.1**	1.5	0.9–2.6	1.4	0.8–2.4
Daily use of mobile phones for phoning, playing games, text messages						
Not at all or not daily	1.0		1.0		1.0	
≤1 h	**1.3**	**1.1–1.5**	**1.2**	**1.1–1.4**	1.1	0.9–1.3
2–3 h	**1.3**	**1.0–1.7**	**1.3**	**1.0–1.7**	1.0	0.8–1.4
4–5 h	0.9	0.5–1.7	0.7	0.4–1.4	0.7	0.3–1.3
>5 h	**2.2**	**1.3–3.7**	**1.9**	**1.1–3.3**	1.7	0.9–3.2
Daily viewing TV, video, or DVD						
Not at all or not daily	1.0		1.0		1.0	
≤1 h	1.0	0.8–1.2	0.9	0.7–1.2	0.9	0.7–1.1
2–3 h	1.0	0.8–1.2	0.9	0.7–1.1	0.8	0.7–1.0
4–5 h	1.1	0.9–1.4	0.9	0.7–1.2	0.8	0.6–1.2
>5 h	1.4	0.9–2.1	1.1	0.7–1.8	0.8	0.4–1.4

a: Model 1, adjusted for age and sex
b: Model 2, adjusted for age, sex, parents' level of education, school success, timing of puberty, efficiency of physical activity
c: Model 3, adjusted for age, sex, parents' level of education, school success, timing of puberty, efficiency of physical activity, stress symptoms
d: The reference category is indicated by an odds ratio of 1. Odds ratios are given in boldface when they indicate a statistically significant difference from the odds of the reference category at 95% CI

Table 3 Risk (OR, 95% CI) for weekly LBP according to use of ICT among 14- to 18-year-old Finns. Separate models for each ICT variable

Exposure to ICT	Model 1[a]		Model 2[b]		Model 3[c]	
	OR	95% CI	OR	95% CI	OR	95% CI
Weekly use of computer						
Not at all	1.0[d]		1.0		1.0	
1–13 h	0.8	0.6–1.0	0.9	0.7–1.2	0.9	0.7–1.3
14–41 h	1.0	0.7–1.4	1.0	0.7–1.5	1.0	0.7–1.5
≥42 h	1.5	0.9–2.6	**1.8**	**1.0–3.2**	**1.7**	**1.0–3.1**
Weekly use of the Internet						
Not at all	1.0		1.0		1.0	
1–13 h	0.8	0.7–1.1	0.9	0.7–1.2	0.9	0.7–1.2
14–41 h	1.1	0.8–1.6	1.1	0.8–1.6	0.9	0.6–1.4
≥42 h	**1.9**	**1.1–3.4**	**2.0**	**1.1–3.7**	**1.8**	**1.0–3.4**
Daily use of computer						
Not at all or not daily	1.0		1.0		1.0	
≤1 h daily	1.0	0.8–1.2	1.1	0.8–1.2	0.9	0.8–1.2
2–3 h daily	1.1	0.8–1.5	1.0	0.8–1.6	0.9	0.6–1.3
4–5 h daily	1.0	0.5–2.1	1.0	0.5–2.1	0.7	0.3–1.6
>5 h daily	**2.3**	**1.2–4.4**	**2.6**	**1.3–5.3**	**2.0**	**1.0–4.2**
Daily playing digital games						
Not at all or not daily	1.0		1.0		1.0	
≤1 h	1.0	0.7–1.2	0.9	0.7–1.2	0.9	0.7–1.1
2–3 h	0.9	0.7–1.2	0.9	0.6–1.2	0.8	0.6–1.1
4–5 h	1.1	0.7–1.9	1.1	0.7–1.9	0.9	0.5–1.6
>5 h	**2.5**	**1.5–4.1**	**2.3**	**1.3–3.9**	**2.0**	**1.1–3.5**
Daily use of mobile phones for phoning, playing games, text messages						
Not at all or not daily	1.0		1.0		1.0	
≤1 h	1.1	0.9–1.3	1.0	0.8–1.2	0.9	0.7–1.1
2–3 h	**1.4**	**1.0–1.9**	1.2	0.9–1.7	1.0	0.7–1.5
4–5 h	1.7	0.9–3.3	1.4	0.6–2.8	1.2	0.5–2.6
>5 h	1.6	0.8–3.1	1.2	0.6–2.6	1.0	0.5–2.3
Daily viewing TV, video, or DVD						
Not at all or not daily	1.0		1.0		1.0	
≤1 h	1.0	0.8–1.3	0.9	0.7–1.2	0.9	0.6–1.2
2–3 h	1.1	0.8–1.4	0.9	0.7–1.2	0.9	0.7–1.2
4–5 h	1.2	0.9–1.7	1.0	0.7–1.4	1.0	0.7–1.4
>5 h	**2.1**	**1.3–3.4**	**1.7**	**1.0–2.9**	1.3	0.7–2.3

a: Model 1, adjusted for age and sex
b: Model 2, adjusted for age, sex, school success, timing of puberty
c: Model 3, adjusted for age, sex, school success, timing of puberty, stress symptoms
d: The reference category is indicated by an odds ratio of 1. Odds ratios are given in boldface when they indicate a statistically significant difference from the odds of the reference category at 95% CI

Discussion

According to this study computer-related activities are positively associated with NSP and LBP among adolescents. Our results bring new information suggesting that computer use exceeding 2 h/day is a threshold for NSP, and exceeding 5 h/day for LBP, and digital gaming exceeding 5 h/day is a threshold for LBP. Times spent on digital gaming and using mobile phones were not associated with NSP, nor were mobile phones use and viewing television associated with LBP after adjusting for confounding factors. This is the first comprehensive attempt to establish a connection between exposure time to computer-related activities and NSP and LBP among adolescents.

In visual display unit work, as in computers, information is displayed on a screen and processed via manual input devices like keyboard and mouse. The devices remaining immobile on the desk, the worker is obliged to maintain the same static posture while working.[25] Computer work means sitting at desk with the neck in flexion position, while the keyboard and mouse operation requires repetitive upper extremity motions. Insufficient recovery after local muscle fatigue is believed to be essential in the genesis of muscular pain in static work.[26] Associations between NSP and LBP and computer use were observed in our study; pain at computer work was more easily felt in the neck and shoulder areas than in the lower back.

We discovered digital gaming to be related to LBP but not to NSP. Playing video games has previously been reported to be a risk factor for LBP among 9-year-olds.[10] Digital game playing as in computers, the Internet, television, and console games is a multiform activity of different postures. Although mostly requiring repetitive hand motion in sitting position, the basic mechanism of gaming relies on dynamic action where players change postures freely and the loading of the upper extremities is minimized. On the other hand, LBP is known to be related to prolonged sitting position,[1] and this is confirmed by our findings when exposure times in digital gaming and computer use were high.

The present study is the first illustration of the lack of an association between using mobile phones and reporting NSP. Adolescents are playing games, sending text messages, and phoning while walking, standing, lying, or sitting, which may overload the upper extremities rather than the low back. However, association with NSP disappeared after controlling stress symptoms. NSP in this case may be a stress symptom rather than an independent risk factor. Subjects with stress may have a lowered threshold of reporting pain symptoms. On the other hand, stress or psychological strain might activate the central nervous system to varying degrees resulting in activation of muscle spindles.[27] Increased muscle tone can lead to painful tensional syndromes,[28] a mechanism that might explain the association between spinal pain and computer-related activities as well. NSP and LBP are known to be multifactorial and the different factors may interact.

Viewing television was associated with LBP when viewing time exceeded 5 h/day, a fact that emerged also in multivariate analysis, only to disappear after controlling for stress symptoms. Some previous studies have shown a correlation between time spent on viewing television and back pain,[1,19,23] while others did not. As an occupation apparently not exerting a load on the upper extremities television viewing was not associated with NSP.

The study was based on a large representative sample. There are limitations associated with the reliability and validity of postal surveys. The response rate of the survey was fairly good, although the rates were lower in boys and older age groups than in girls and younger age groups. An indirect analysis of non-respondents showed that there were no systematic or statistically significant differences in the symptom categories or in the ICT variables between respondents and non-respondents. Test–retest reliability in regard to the exposure time of symptoms and ICT variables was good. True daily variation in ICT use and occurrence of symptoms lowers the test–retest reliability. Three different questions measured the daily and weekly computer use, and their relationships to NSP and LBP produced parallel results. Case definition was based on the frequency of pain, but pain intensity and disability caused by symptoms might have provided a more thorough picture.

In conclusion, our results suggest that increased computer-related activities are an independent risk factor for NSP and LBP in adolescence. It is possible, even obvious, that with these modern leisure activities adolescents are confronted with a new health risk. NSP and LBP are signs of physical and mental loading. Musculoskeletal symptoms are common among the middle-aged and people in work life in general. Supposing that these symptoms now emerge 20 years earlier in a lifespan than in previous generations, we can expect increasing sick leaves and early retirements. An increasing proportion of work force will perform their work career in information and communication work, using computers every day. Long-term studies and ergonomic interventions are needed to prevent health risks involved in computer-related activities.

Acknowledgements

Contributors: A.R. initiated and designed the study. L.S. and J.J.S. provided critical input in all phases of the study. P.T.H. and A.R. performed the main analysis, drafted the paper and coordinated subsequent revisions with the other authors. P.T.H., A.R., and J.J.S. are the guarantors for the paper. We express our gratitude to Mr Lasse Pere for data management and to Mrs Marja Vajaranta for revising the language. This study was funded by the Ministry of Social Affairs and Health, the Health Promotion Research Program of the Academy of Finland, the Medical Research Fund of the Tampere University Hospital, the City of Helsinki Health Centre, and the Information Society Institute of the University of Tampere.

Competing interests: None declared.

Key points

- Neck–shoulder pain (NSP) and low back pain (LBP) increased among adolescents in the 1990s simultaneously with the increase in use of information and communication technology (ICT).
- We study how the use of ICT is related to NSP and LBP in adolescents.
- Risk of NSP increased when computer use was 2–3 h/day, or more.
- Risk of LBP increased when computer use and playing digital games exceeded 5 h/day.
- With ICT-involving leisure activities adolescents are confronted with a new health risk.

References

1 Balagué F, Troussier B, Salminen JJ. Non-specific low back pain in children and adolescents: risk factors. *Eur Spine J* 1999;8:429–38.

2 Mikkelsson M, Salminen JJ, Kautiainen H. Non-specific musculoskeletal pain in preadolescents. Prevalence and 1-year persistence. *Pain* 1997;73:29–35.

3 Mikkelsson M, Sourander A, Salminen J, et al. Widespread pain and neck pain in schoolchildren. A prospective one-year follow-up study. *Acta Paediatr* 1999;88:1119–24.

4 Niemi S, Levoska S, Kemilä J, et al. Neck and shoulder symptoms and leisure time activities in high school students. *J Orthop Phys Ther* 1996;24:25–9.

5 Vikat A, Rimpelä M, Salminen J, et al. Neck or shoulder pain and low back pain in Finnish adolescents. *Scand J Public Health* 2000;28:164–73.

6 Hakala P, Rimpelä A, Salminen J, et al. Back, neck, and shoulder pain in Finnish adolescents: national cross sectional surveys. *Br Med J* 2002;325::743–5.

7 Currie C, Hurrelmann K, Settertobulte W, et al. Health and health behaviour among young people. Health Behaviour in School-aged Children: a WHO Cross-National Study (HBSC) International rapport years 1997–98. 2000:36.

8 King A, Wold B, Tudor-Smith C, Harel Y. The health of youth. A cross-national survey. *WHO Reg Publ Eur Ser* 1996;69:68–9.

9 Niemi I, Pääkkönen H. *Ajankäytön muutokset 1990-luvulla*. (In Finnish: Changes in the Use of Time in the 1990s.). Helsinki, In Tilastokeskus, kulttuuri ja viestintä, 2001.

10 Gunzburg R, Balagué F, Nordin M, et al. Low back pain in a population of school children. *Eur Spine J* 1999;8:439–43.

11 Niemi SM, Levoska S, Rekola KE, Keinänen-Kiukaanniemi SM. Neck and shoulder symptoms of high school students and associated psychosocial factors. *J Adolesc Health* 1997;20:238–42.

12 Rossignol AM, Morse EP, Summers VM, Pagnotto LD. Video display terminal use and reported health symptoms among Massachusetts clerical workers. *J Occup Med* 1987;29:112–8.

13 Cook C, Burgess-Limerick R, Chang S. The prevalence of neck and upper extremity musculoskeletal symptoms in computer mouse users. *Int J Ind Ergon* 2000;26:347–56.

14 Korhonen T, Ketola R, Toivonen R, et al. Work related and individual predictors for incident neck pain among office employees working with video display units. *Occup Environ Med* 2003;60:475–82.

15 Palmer KT, Cooper C, Walker-Bone K, et al. Use of keyboards and symptoms in the neck and arm: evidence from a national survey. *Occup Med* 2001;51:392–5.

16 Gerr F, Marcus M, Ensor C, et al. A prospective study of computer users: I. Study design and incidence of musculoskeletal symptoms and disorders. *Am J Ind Med* 2002;41:221–35.

17 Ketola R, Toivonen R, Häkkänen M, et al. Effects on ergonomic intervention in work with video display units. *Scand J Work Environ Health* 2002;28:18–24.

18 Jacobs K, Baker NA. The association between children's computer use and musculoskeletal discomfort. *Work* 2002;18:221–6.

19 Sjolie AN. Associations between activities and low back pain in adolescence. *Scand J Med Sci Sports* 2004;14:352–9.

20 Burke A, Peper E. Cumulative trauma disorder risk for children using computer products: results of a pilot investigation with a student convenience sample. *Public Health Rep* 2002;117:350–7.

21 Harris C, Straker L. Survey of physical ergonomics issues associated with school childrens' use of laptop computers. *Int J Ind Ergon* 2000;26:337–46.

22 Alexander LM, Currie C. Young people's computer use: implications for health education. *Health Educ* 2004;4:254–61.

23 Kristjansdottir G, Rhee H. Risk factors of back pain frequency in schoolchildren: a search for explanations to a public health problem. *Acta Paediatr* 2002;91:849–54.

24 Statistical Yearbook of Finland 2004. Education and research. Official Statistics Finland. Helsinki, Finland, 2004.

25 Aarås A, Horgen G, Ro O. Work with the visual display unit: Health consequences. *Int J Hum Comput Interact* 2000;12:107–34.

26 Sjögaard G, Lundberg U, Kadefors R. The role of muscle activity and mental load in the development of pain and degenerative processes at the muscle cell level during computer work. *Eur J Appl Physiol* 2000;83:99–105.

27 Alfven G. Psychosomatic pain in children: a psychomuscular tension reaction? Review article *Eur J Pain* 1997;1:5–15.

28 Simons DG, Mense S. Understanding and measurement of muscle tone as related to clinical muscle pain. Review article. *Pain* 1998;75:1–17.

Received 7 May 2005, accepted 8 December 2005