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Risk factors for generally reduced productivity—a prospective cohort study of young adults with neck or upper-extremity musculoskeletal symptoms

by Maria Boström,¹ Lotta Dellve, PhD,¹ Sara Thomée, MSc,¹ Mats Hagberg, MD¹

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Objectives This study prospectively assessed the importance of individual conditions and computer use during school or work and leisure time as risk factors for self-reported generally reduced productivity due to musculoskeletal complaints among young adults with musculoskeletal symptoms in the neck or upper extremities.

Methods A cohort of 2914 young adults (18–25 years, vocational school and college or university students) responded to an internet-based questionnaire concerning musculoskeletal symptoms related to individual conditions and computer use during school or work and leisure time that possibly affected general productivity. Prevalence ratios (PR) were used to assess prospective risk factors for generally reduced productivity.

Results The selected study sample (N=1051) had reported neck or upper-extremity symptoms. At baseline, 280 of them reported reduced productivity. A follow-up of the 771 who reported no reduced productivity was carried out after 1 year. Risk factors for self-reported generally reduced productivity for those followed-up were symptoms in two or three locations or dimensions for the upper back or neck and the shoulders, arms, wrists, or hands [PR 2.30, 95% confidence interval (95% CI) 1.40–3.78], symptoms persisting longer than 90 days in the shoulders, arms, wrists, or hands (PR 2.50, 95% CI 1.12–5.58), current symptoms in the shoulders, arms, wrists, or hands (PR 1.78, 95% CI 1.10–2.90) and computer use 8–14 hours/week during leisure time (PR 2.32, 95% CI 1.20–4.47). A stronger relationship was found if three or four risk factors were present. For women, a relationship was found between generally reduced productivity and widespread and current symptoms in the upper extremities.

Conclusions The main risk factors for generally reduced productivity due to musculoskeletal symptoms among young adults in this study were chronic symptoms in the upper extremities and widespread symptoms in the neck and upper extremities.

Key terms computer use; efficiency; musculoskeletal disorder; performance; presenteeism.

Little is known about the relationship between musculoskeletal symptoms, computer use, and generally reduced productivity. There are few studies on the influence of individual conditions and computer use at school or work and during leisure time on the development of self-reported, generally reduced productivity in the early stages of musculoskeletal complaints and how these factors interact. Furthermore, the younger working population may be exposed in different ways to today's increased information technology. More extensive knowledge in this area could enhance the development of methods to prevent productivity loss among young adults with musculoskeletal symptoms.

In a work-system model (1) a balance between work elements (tasks, technique, organization, environment) and individual and leisure-time conditions is desirable

to prevent musculoskeletal disorders (2) and work disability (3). This study focused on the importance of task-related elements in combination with individual and leisure-time conditions for generally reduced productivity.

Reduced productivity implies work attendance but lower production and effectiveness (4, 5). The term “presenteeism” has been used in similar ways (6–9), sometimes as “decreased presenteeism” (10) or as “sickness presenteeism” describing work attendance despite sickness (11).

Both before and after a period of sickness, reduced productivity can occur. Brouwer et al (12) found that, among employees of a trade firm, 25% of the respondents experienced productivity loss before an illness, and 20% felt such a loss after an absence. Reduced productivity

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after sick leave due to musculoskeletal disorders among blue-collar workers has also been studied by Lötters et al (13). They found a median loss of 1.6 hours for an 8-hour day among workers who experienced productivity loss. Reduced productivity can also occur without absence due to health problems (14).

Reduced productivity increases the indirect costs of the employer. In a study of nearly 29 000 workers, health-related lost production cost employers USD 1685 per employee yearly; of this amount, 71% could be explained by reduced performance at work (15). Goetzel et al (9) found that the costs of productivity loss were higher than medical costs for 10 health conditions, for example, allergy, arthritis, depression, and hypertension. Collins et al (16) established that costs associated with reduced productivity caused by various illnesses, including neck or back disorders, greatly exceeded the combined costs of absenteeism and medical treatment. In a Swedish study by Hagberg et al (17), the authors estimated that musculoskeletal symptoms were related to a hidden productivity loss of USD 504 per employee yearly in a company with 50 employees. Recently new recommendations for estimating the costs of health-related productivity loss were published (18).

Methods to measure reduced productivity have been developed (5, 7, 19) for disorders such as depression, rheumatoid arthritis, migraine headaches, sleep disorders, and diabetes (20–24) or health risks (8, 25). Some studies with a cross-sectional study design have reported possible correlations between musculoskeletal symptoms and productivity loss (4, 8, 15–17, 26). However, Hagberg et al (17) identified prospective risk factors for reduced productivity due to musculoskeletal complaints. All of the studies focused on adult populations.

Hagberg et al (17) showed that reduced productivity occurred among male and female computer users (20–65 years of age) with musculoskeletal symptoms. The mean magnitude of the self-reported reduction was 15% for the women and 13% for the men. An association with symptom persistence and reduced productivity was found for both genders. An association was also found with depressive symptoms and divorce or marital separation and productivity loss among the women. Other individual factors, such as overweight (body mass index of $>25 \text{ kg/m}^2$) (27), has been found to be a risk factor for reported reduced productivity (28–30). Among smokers, production loss due to personal health was found to be twice as high as for nonsmokers (15). Furthermore, distress, depression, high stress, and fatigue have been shown to be risk factors for productivity loss among adults (8, 16, 25, 28, 31). For young adults, depression has been found to be associated with reduced productivity (32, 33), and tension headaches or migraine headaches have also shown the same association for this group (34, 35).

Few studies, to our knowledge, have shown the possible relationships between ergonomic work factors and productivity. In the previously mentioned study of computer users by Hagberg et al (17), the results indicated an association between computer tasks, computer mouse position, work demands, and productivity loss. In a follow-up study (30), a similar association was found for computer time and the time used to operate a computer mouse. Moreover, the same relationship has been shown for work demands (30, 36)

There is little knowledge on how lifestyle risk factors influence productivity. Hagberg et al (30) found that exercising fewer than eight times in the past month was a risk factor for reduced productivity due to neck, shoulder, and forearm or hand symptoms. Burton et al (37) reported increased worker productivity for those who trained at a worksite fitness center. Moreover, non-participants were more likely to report health-related, productivity limitations and overall work impairment.

In summary, the following risk factors for reduced productivity have been found in adult populations: symptom persistence, depressive symptoms, overweight, smoking, high general distress level, computer time, various computer tasks, computer mouse position and operating time, work demands and inactivity, and, for young adults, depression and tension headaches or migraine headaches.

The aforementioned risk factors were found in an adult population. Notwithstanding the importance of studying newly exposed workers (eg, young adults at the age of entering worklife) (38), few studies have concerned musculoskeletal disorders and productivity in a young adult population. Siivola et al (39) found a high incidence of neck and shoulder pain among young adults aged 15–18 years in a prospective study. Early neck and shoulder pain and stress-related symptoms were prospectively related to pain at 22–25 years of age among the females. Eriksson et al (40) found important gender differences for good health and health-related performance among young male and female adults. Yet, to our knowledge, no prospective results of the development of productivity losses among young adults with musculoskeletal symptoms have been previously reported.

The aim of our study was to prospectively assess individual conditions (including lifestyle and symptoms) and computer use during school or work and leisure time as possible risk factors for self-reported generally reduced productivity due to musculoskeletal complaints among young adults with musculoskeletal symptoms from the upper back or neck or shoulders or arms.

The specific research questions were (i) are individual conditions (body mass index, civil status, physical activity, breakfast habits, smoking, snuff use, alcohol consumption, current symptoms, duration and distribution of symptoms, depression, difficulties in

falling asleep and stress) risk factors for self-reported generally reduced productivity among young adults with musculoskeletal neck, shoulder or arm symptoms and (ii) is computer use in school or work and during leisure time (amount of computer use, breaks from the computer, computer tasks, computer mouse use, and productivity demands) a risk factor for self-reported generally reduced productivity among young adults with musculoskeletal neck, shoulder or arm symptoms?

Study population and methods

Study design

Our study was a prospective study with a 1-year follow-up of young adults, at the age when they were about to enter worklife. Baseline and follow-up data were collected using an Internet-based questionnaire. Initially, a cross-sectional analysis was performed to describe the baseline data and as a guideline for possible risk factors. The cohort was the base for a large prospective cohort study called Productivity, Health and Creativity in Relation to the Use of Computers, Telecommunication and Media—a 10-Year Cohort Study.

Study population

The source population consisted of 5786 vocational school and college or university students (age range

18–25 years) in health care, engineering, information technology, and medical and nursing studies who were invited to respond to an Internet-based questionnaire. The students were obtained through enrollment lists provided by the schools. The cohort consisted of 2914 respondents. The response frequency was 68–75% for the college or university students and 15–27% for the vocational school students. The respondents were followed-up after 1 and 2 years (response frequency 87% and 75%, respectively).

The study group, 1051 students, included young adults with symptoms at baseline. It also included students without symptoms at baseline that had symptoms at the 1-year follow-up. As well, it included students who did not have symptoms at baseline or at the 1-year follow-up but had symptoms at the 2-year follow-up (figure 1). All of these persons formed the study group including students with symptoms. This procedure enabled us to include participants to the study prospectively. Each participant in the study group was followed up after 1 year. The inclusion criteria for the study group were current pain or ache in the upper back or neck, current pain or ache in the shoulders, arms, wrists, or hands, or current numbness or a tingling sensation in the hand or fingers. The duration of symptoms was ≥1 days. In the study group, 80% were college or university students, and 20% were vocational school students. At baseline, 280 students in the study group reported reduced productivity due to musculoskeletal symptoms during the last month and were excluded from the prospective

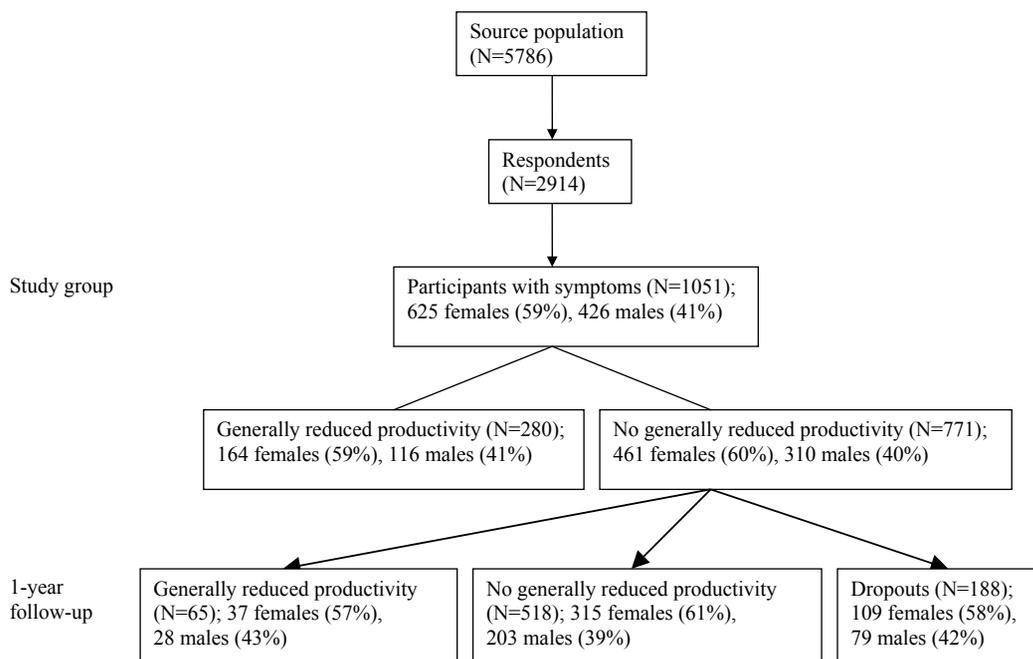


Figure 1. The study group formed out of the respondents from the source population. The study group consisted of the participants that reported symptoms. For those for whom symptoms did not generally affect productivity (N=771), a follow-up was carried out after 1 year.

analysis. Of the 771 remaining persons, 188 did not complete the questionnaire at the 1-year follow-up, the response frequency being 76%. For variables such as gender, symptom duration, and symptom distribution, a dropout analysis showed no major differences between the group followed prospectively and the dropouts. At the 1-year follow-up, 65 persons of the 583 participants (excluding dropouts) reported reduced productivity. The 65 cases were defined as persons who reported symptoms in agreement with the inclusion criteria and also reported generally reduced productivity.

Data collection

The Internet-administered questionnaire consisted of 45 items and had an alignment to information and communication technology (ICT) use and health with questions concerning individual factors including lifestyle and symptoms, computer use during school or work and leisure time, and productivity. The questionnaire was designed from several earlier questionnaires used in Sweden and validated in Swedish reports. Items on computer use have been validated and presented earlier (41). The present questionnaire underwent expert validation by Statistics Sweden.

Generally reduced productivity

The studied outcome “generally reduced productivity” was measured by the single-item question “Has pain or ache in muscles or joints affected your general productivity during the preceding month (answer ‘yes/no’)?” The item “If your productivity has decreased, please state how much in percent when compared with when you have no symptoms” was used for descriptive purposes. These two items have been used and qualitatively validated among a group of 50 computer users and recently tested among 16 young adults (not yet published).

Individual factors, lifestyle and symptoms

The questionnaire dealt with factors such as gender, age, height, weight, civil status, tobacco use, and alcohol use. Furthermore, the questionnaire contained questions about symptoms, pain or ache in the upper back or neck, pain or ache in the shoulders, arms, wrists or hands, and numbness or a tingling sensation in hand or fingers, as well as about current symptoms and their duration. There were also questions on current perceived stress (42), validated by Elo et al (43), symptoms of depression (44), and difficulties in falling asleep (45).

Several exposures were divided into two or three levels (low or high exposure or low, moderate or high exposure). Body mass index (BMI) was categorized

into $<25 \text{ kg/m}^2$ and $\geq 25 \text{ kg/m}^2$ from the definition for overweight (27). Physical activity was defined as the duration of exercise in hours or training in the last week and was divided into three categories (<2 , 2–4, and >4 hours). Breakfast habits were divided into two groups (0–2 times/week as high exposure and 3–7 times/week as low exposure). Tobacco use was categorized into current smoker or snuff user and not a smoker or snuff user, and alcohol use was recorded as total abstainer or alcohol user. The duration of musculoskeletal symptoms was divided into three levels as low (1–30 days = acute), moderate (31–90 days = subacute), and high (>90 days = chronic) based on the definition of chronic pain (46). The location or dimension of symptoms was divided into one, two, or three symptoms, and more than one location or dimension was called “widespread symptoms”. The variable “current stress”, defined as a condition of tenseness, restlessness, or worry or having difficulties sleeping at night due to problem fixation, was divided into three levels as (i) low, not at all or slight, (ii) moderate, responding to some extent, and (iii) high, rather much or very much. Difficulties in falling asleep during the last 6 months was divided into the following three levels: (i) low = never, once or a few times a year, (ii) moderate = once or a few times a month, and (iii) high = several times/week or daily. The variable “symptoms of depression” contained the following two items: (i) little interest or pleasure in doing things and (ii) feeling low, depressed, or hopeless during the last 30 days. Low exposure was defined as neither of the two items, moderate as one item, and high as both items.

Computer use at school or work and during leisure time

Computer factors for school or work, such as computer time, differing computer tasks, computer mouse use, breaks during computer use, and productivity demands, were also asked for. Total computer time was assessed as a combined school or work and leisure-time factor. Leisure-time factors such as computer time and nature of computer tasks were registered.

The duration of computer mouse use was divided into three levels (0–25% computer mouse time = low exposure, 50% = moderate exposure, and 75–100% = high exposure) on the basis of the report of Brandt et al (47). Using the computer longer than 4 hours without a break (>10 minutes) was divided into 0–1 time/week (low exposure), 2–4 times/week (moderate), and ≥ 5 times/week (high exposure). Demands were expressed as experienced productivity demands in the study or work situation and were divided into the following three levels: low exposure = partly or entirely in agreement with “excessively low demands”, moderate = partly or entirely in agreement with “neither excessively low nor excessively

high demands”, and high exposure = partly or entirely in agreement with “excessively high demands”. Total computer time at school or work and during leisure time was divided into three levels as 1–9 hours/week (low exposure), 10–29 hours/week (moderate exposure), and ≥ 30 hours/week (high exposure) on the basis of established risk levels for computer time, 75% of worktime (48) and computer time of >4 hours/day being associated with musculoskeletal disorders (49). Laptop use was excluded, as only 26% of the students used one a few hours a week. The computer time during leisure time was separated into three levels that were similar to those used for total computer time, but with the exposure time halved.

Data analysis and statistics

The Cox proportional hazard regression model was used for all of the analyses, both cross-sectional and prospective. The analyses were performed with the statistical software package SAS, version 9.1 (SAS Institute, Cary, NC, USA), and “proc phreg” in SAS was used with the time set to 1 to obtain the prevalence ratios. The analyses were performed for the entire group, as well as for the male and female students separately.

A cross-sectional analysis of the study group with musculoskeletal symptoms was performed to examine possible correlations between different factors and reduced productivity. Prevalence ratios (PR) were computed separately for the groups with or without reduced productivity.

The 1-year prospective analysis was performed with the exclusion of those in the study group with perceived reduced productivity at baseline to assess risk factors for reduced productivity. The correlations between the risk factors were tested. The multivariate analysis was performed with all of the significant risk factors ($P \leq 0.05$), and, furthermore, a model based on the four main risk factors was created to examine the effect of a combination of risk factors.

Results

Characteristics of the study group

In the study group, 27% of the students with musculoskeletal symptoms reported generally reduced productivity at baseline ($N=280$), 82% of them were college or university students, and 18% were vocational school students. Among the group who did not report any generally reduced productivity ($N=771$), 79% were college or university students, and 21% were vocational school students. About half of the respondents in the study

group ($N=1051$) had had symptoms ≥ 7 days (40–56%, depending of the location of the symptoms). The mean magnitude of the reduction was 21 (median 15, range 2–90)% for the female students and 18 (median 10, range 1–100)% for the male students. Several individual conditions and computer use factors of the school, work, and leisure time were cross-sectionally associated with generally reduced productivity (table 1).

Prospective risk factors for reduced productivity

The cumulative incidence of self-reported generally reduced productivity was 0.11 (65 cases among 583 students). Of these, 47 cases occurred among the college or university students, and 18 cases involved vocational school students. Relationships were found between different factors and generally reduced productivity (table 2).

Widespread symptoms (two or more locations or dimensions of symptoms in the upper back or neck and shoulders, arms, wrists, or hands) compared with symptoms in one location or dimension showed the strongest relationship with generally reduced productivity. Furthermore, current and long-term (>90 days) symptoms in the shoulders, arms, wrists, or hands were also prospectively related to generally reduced productivity. Widespread and current symptoms were consistent for the female students, but not for the male students. In addition, we found a relationship between computer use during leisure time (8–14 versus 0–7 hours/week) and generally reduced productivity and difficulties in falling asleep one or a few times per month and generally reduced productivity.

The presence of three or four risk factors showed a strong relationship to generally reduced productivity (table 3); this finding indicates the importance of a combination of risk factors.

No relationship between generally reduced productivity and gender, BMI, civil status, tobacco use, alcohol use, physical activity, weekday breakfast habits, productivity demands at school or work, depressive symptoms, breaks during computer use, computer mouse use, or computer tasks were established. The multivariate analysis did not show any relationships between the risk factors.

Concordance between cross-sectional and prospective risk factors

The cross-sectional and prospective results were in agreement for an association between generally reduced productivity and two of the risk factors, current symptoms in the shoulders, arms, wrists, or hands and widespread symptoms in the upper back or neck and shoulders, arms, wrists or hands.

Table 1. Associations between different individual factors (including lifestyle and symptoms), computer use at school or work and during leisure time, and generally reduced productivity in the study group at baseline.^a (N = number of students, PR=prevalence ratios, 95% CI = 95% confidence interval)

	Participants with musculoskeletal symptoms						PR	95% CI
	All (N=1051)		No generally reduced productivity (N=771)		Generally reduced productivity (N=280)			
	N	%	N	%	N	%		
<i>Individual factors</i>								
Body mass index								
<25 kg/m ²	874	83.2	636	82.5	238	85.0	1.00	..
≥25 kg/m ²	177	16.8	135	17.5	42	15.0	0.87	0.63–1.21
Civil status								
Cohabiting or married	291	27.7	213	27.6	78	27.9	1.00	..
Single	726	69.1	530	68.7	196	70.0	1.03	0.77–1.31
Lifestyle factors								
Physical activity								
<2 hours/week	315	30.0	232	30.1	83	29.6	1.00	..
2–4 hours/week	402	38.2	303	39.3	99	35.4	0.93	0.70–1.25
>4 hours/week	334	31.8	236	30.6	98	35.0	1.11	0.83–1.49
Breakfast habits								
3–7 times/week	960	91.3	706	91.6	254	90.7	1.00	..
1–2 times/week	91	8.7	65	8.4	26	9.3	1.08	0.72–1.62
Smoking								
Nonsmoker	929	88.4	687	89.1	242	86.4	1.00	..
Current smoker	114	10.8	77	10.0	37	13.2	1.25	0.89–1.77
Snuff use								
Not snuff user	941	89.5	688	89.2	253	90.4	1.00	..
Current snuff user	104	9.9	77	10.0	27	9.6	0.97	0.65–1.44
Alcohol consumption								
Total abstainer	93	8.8	66	8.6	27	9.6	1.00	..
Not total abstainer	956	91.0	705	91.4	251	89.6	0.86	0.59–1.26
<i>Symptoms</i>								
Current pain or ache in upper back or neck								
No	283	26.9	222	28.8	61	21.8	1.00	..
Yes	768	73.1	549	71.2	219	78.2	1.32	1.00–1.76
Current pain or ache in shoulders, arms, wrists or hands								
No	597	56.8	479	62.1	118	42.1	1.00	..
Yes	454	43.2	292	37.9	162	57.9	1.80	1.42–2.29
Current numbness or a tingling sensation in hands or fingers								
No	882	83.9	645	83.7	237	84.6	1.00	..
Yes	169	16.1	126	16.3	43	15.4	0.95	0.68–1.31
Current symptom location or dimension								
One	760	72.3	599	77.7	161	57.5	1.00	..
Two	242	23.0	148	19.2	94	33.6	1.83	1.42–2.36
Three	49	4.7	24	3.1	25	8.9	2.41	1.58–3.67
Duration of pain or ache in upper back or neck								
1–30 days	340	32.4	266	34.5	74	26.4	1.00	..
31–90 days	69	6.6	48	6.2	21	7.5	1.40	0.86–2.27
>90 days	356	33.9	233	30.2	123	43.9	1.59	1.19–2.12
Duration of pain or ache in shoulders, arms, wrists or hands								
1–30 days	170	6.7	115	1.9	55	19.6	1.00	..
31–90 days	51	4.9	34	4.4	17	6.1	1.03	0.60–1.78
>90 days	230	21.9	142	18.4	88	31.4	1.18	0.84–1.66
Duration of numbness or a tingling sensation in hand or fingers								
1–30 days	61	5.8	46	6.0	15	5.4	1.00	..
31–90 days	20	1.9	17	2.2	3	1.1	0.61	0.18–2.11
>90 days	85	8.1	60	7.8	25	8.9	1.20	0.63–2.27
Current stress								
Not at all–a little	446	42.4	350	45.4	96	34.3	1.00	..
To some extent	256	24.4	189	24.5	67	23.9	1.22	0.89–1.66
Rather much–very much	349	33.2	232	30.1	117	41.8	1.56	1.19–2.04

(continued)

Table 1. Continued.

	Participants with musculoskeletal symptoms						PR	95% CI
	All (N=1051)		No generally reduced productivity (N=771)		Generally reduced productivity (N=280)			
	N	%	N	%	N	%		
Difficulties falling asleep in last half year								
Never, once or a few times per year	409	42.2	312	40.5	97	34.6	1.00	..
Once or a few times per month	348	35.9	255	33.1	93	33.2	1.13	0.89–1.43
Several times per week or every day	213	22.0	144	18.7	69	24.6	1.37	1.00–1.86
Symptoms of depression last month, N=684								
No symptom	252	24.0	183	37.8	69	34.5	1.00	..
One symptom	206	19.6	150	31.0	56	28.0	0.99	0.70–1.41
Two symptoms	226	21.5	151	31.2	75	37.5	1.21	0.87–1.68
<i>Computer use</i>								
At school or work and during leisure time								
Total computer time last week								
1–9 hours/week	399	38.1	297	38.5	102	36.4	1.00	..
10–29 hours/week	308	29.3	227	29.4	81	28.9	1.03	0.77–1.38
≥30 hours/week	227	21.6	156	20.2	71	25.4	1.22	0.90–1.66
During leisure time last week								
1–7 hours/week	435	41.4	314	40.7	121	43.2	1.00	..
8–14 hours/week	144	13.7	109	14.1	35	12.5	0.87	0.60–1.27
≥15 hours/week	212	20.2	152	19.7	60	21.4	1.02	0.75–1.39
>4 hours without breaks last week								
0–1 times/week	693	65.9	512	66.4	181	64.6	1.00	..
2–4 times/week	234	22.3	168	21.8	66	23.6	1.08	0.82–1.43
≥5 times/week	124	11.8	91	11.8	33	11.8	1.02	0.70–1.48
Mouse use of computer time last week								
0–25%	345	32.8	260	33.7	85	30.4	1.00	..
50%	391	37.2	273	35.4	118	42.1	1.22	0.93–1.62
75–100%	315	30.0	238	30.9	77	27.5	0.99	0.73–1.35
Image management on the computer during leisure time last week								
No	937	89.2	700	90.8	237	84.6	1.00	..
Yes	114	10.8	71	9.2	43	15.4	1.49	1.08–2.06
<i>Current productivity demands</i>								
Too low	59	6.6	44	5.7	15	5.4	1.00	..
Neither too low or too high	472	44.9	356	46.2	116	41.4	0.97	0.56–1.65
Too high	520	49.5	371	48.1	149	53.2	1.13	0.66–1.92

^a The figures in boldface were statistically significant (the lower limit of the 95% CI being ≥1.00).

A cross-sectional association was found between generally reduced productivity and symptoms from the upper back or neck, and a prospective relationship was found with symptoms in the upper extremities for the same duration. Computer use during leisure time showed no cross-sectional association, but did have a prospective relationship. Likewise, difficulties in falling asleep several times a week or every day were cross-sectionally, but not prospectively, associated with generally reduced productivity. Furthermore, several associations with generally reduced productivity occurred only at baseline (current and chronic neck symptoms, stress, computer tasks as information search in school or work, and image management during leisure time).

Discussion

Prospective individual risk factors for generally reduced productivity

Our results indicated that the most important risk factors for self-reported generally reduced productivity among young adults with musculoskeletal symptoms was widespread symptoms in the upper back or neck and in the shoulders, arms, wrists, or hands in comparison with symptoms in one location or dimension. We found a relationship between symptoms in two or three locations or dimensions and generally reduced productivity. If complaints were considerable, they seemed to influence

Table 2. Risk factors for self-reported generally reduced productivity at the follow-up for the study group (those with generally reduced productivity at baseline excluded) and for the female and male students with symptoms separately, adjusted for gender.^a (N = number of students, PR=prevalence ratios, 95% CI = 95% confidence interval)

Risk factors at baseline	Generally reduced productivity at follow-up											
	All students (N=583)				Female students (N=352)				Male students (N=231)			
	Exposed (N)	Cases (N)	PR	95% CI	Exposed (N)	Cases (N)	PR	95% CI	Exposed (N)	Cases (N)	PR	95% CI
Current pain or ache in upper back or neck	422	49	1.17	0.66–2.05	277	31	1.40	0.58–3.35	145	18	1.07	0.49–2.31
Current pain or ache in shoulders, arms, wrists or hands	222	34	1.78	1.10–2.90	124	21	2.41	1.26–4.62	98	13	1.18	0.56–2.47
Current numbness or a tingling sensation in hands or fingers	86	12	1.31	0.70–2.45	46	7	1.55	0.68–3.53	40	5	1.04	0.40–2.73
Current symptom distribution (reference category one location or dimension, N=583)												
Two or three locations or dimensions	131	26	2.30	1.40–3.78	85	19	3.32	1.74–6.32	46	7	1.34	0.57–3.15
Duration of pain or ache in upper back or neck (reference category 1–30 days, N=420)												
31–90 days	37	4	1.05	0.36–3.06	23	1	0.43	0.06–3.24	14	3	2.05	0.53–7.93
>90 days	179	23	1.25	0.69–2.26	117	16	1.34	0.65–2.74	62	7	1.08	0.38–3.08
Duration of pain or ache in shoulders, arms, wrists or hands (reference category 1–30 days, N=222)												
31–90 days	24	3	1.44	0.38–5.42	14	2	1.46	0.28–7.51	10	1	1.37	0.14–13.14
>90 days	106	23	2.50	1.12–5.58	59	14	2.42	0.87–6.72	47	9	2.62	0.71–9.67
Duration of numbness or a tingling sensation in hands or fingers (reference category 1–30 days, N=84)												
31–90 days	9	1	0.69	0.08–5.90	5	1	1.70	0.15–18.75	4	0
>90 days	44	6	0.84	0.26–2.77	22	4	1.54	0.28–8.44	22	2	0.42	0.07–2.54
Current stress (reference category not at all–a little, N=583)												
To some extent	147	17	1.21	0.65–2.24	99	9	1.25	0.50–3.16	48	8	1.43	0.61–3.34
Rather much–very much	175	23	1.37	0.78–2.42	129	19	2.03	0.92–4.48	46	4	0.74	0.25–2.23
Difficulties in falling asleep in last half year (reference category never, once or a few times per year, N=534)												
Once or a few times per month	194	30	1.79	1.01–3.14	130	18	1.70	0.79–3.69	64	12	2.02	0.88–4.69
Several times per week or every day	109	14	1.48	0.75–2.94	73	9	1.52	0.62–3.73	36	5	1.50	0.51–4.39
Symptoms of depression last month (reference category no symptom, N=413)												
One symptom	128	14	1.17	0.56–2.42	75	10	2.27	0.78–6.63	53	4	0.57	0.18–1.80
Two symptoms	125	19	1.62	0.82–3.19	86	13	2.57	0.92–7.21	39	6	1.15	0.42–3.18
Total computer time last week (reference category 1–9 hours/week, N=521)												
10–29 hours/week	174	26	1.64	0.92–2.91	96	11	1.17	0.54–2.53	78	15	2.54	0.92–6.98
≥30 hours/week	117	10	0.94	0.44–1.99	44	4	0.93	0.31–2.79	73	6	1.08	0.33–3.55
Computer use during leisure time last week (reference category 1–7 hours/week, N=457)												
8–14 hours/week	88	16	2.32	1.20–4.47	41	7	2.47	0.98–6.19	47	9	1.83	0.68–4.92
≥15 hours/week	113	13	1.47	0.73–2.95	35	5	0.98	0.36–2.71	78	8	2.07	0.74–5.80
Image management on the computer during leisure time during previous week	219	27	1.21	0.55–2.64	143	15	1.46	0.45–4.77	76	12	1.00	0.35–2.88

^a The figures in boldface were statistically significant (the lower limit of the 95% CI being ≥1.00).

productivity. There is, to our knowledge, no known research about the relationship between widespread symptoms and productivity. However, widespread pain has been shown to predict sickness absence among adult industrial workers (50).

Another factor related to generally reduced productivity among young adults with symptoms was the duration of the symptoms in the shoulders, arms, wrists, or hands. This result is consistent with findings among adults (17), whereby symptoms lasting at least 7 days were a risk factor for the reporting of reduced productivity. About half of the persons in our study group had had symptoms ≥7 days. According to our results for young

Table 3. Combination of one to four prospective risk factors at baseline and self-reported generally reduced productivity at the 1-year follow-up.^a (PR = prevalence ratio, 95% CI = 95% confidence interval)

Risk factors	PR	95% CI
One factor present	0.81	0.35–1.87
Two factors present	1.61	0.82–3.14
Three factors present	2.74	1.42–5.26
Four factors present	4.85	1.99–11.82

^a The factors were widespread symptoms in the neck, shoulders and arms, chronic symptoms in the shoulders or arms, current symptoms in the shoulders or arms, and computer use during leisure time. The factor difficulties in falling asleep was excluded from this model.

adults, it appears that only symptoms of more than 90 days influence productivity. These findings are in accord with the definition of chronic pain (46). Moreover, Collins et al (16) found that the presence of a chronic condition, for example, neck disorders, was the most important determinant of the reported levels of work impairment, and Penny et al (51) observed that chronic pain affected physical, social, and psychological well-being among adult patients with chronic pain.

Furthermore, a relationship was found between current pain or ache in the shoulders, arms, wrists, or hands and generally reduced productivity, but was not found between generally reduced productivity and current pain or ache in the upper back or neck or numbness or a tingling sensation in the hands or fingers. Perhaps symptoms in the shoulders, arms, wrists, or hands generate higher pain intensity than do symptoms in the upper back or neck or numbness or a tingling sensation in the hands or fingers and consequently more strongly influence productivity. Unfortunately, the intensity of the symptoms was not reported, and it therefore remains a theoretical explanation. Moreover, the response alternative for pain or ache in the shoulder or arm contains the possibility for symptoms from a larger area than other symptoms do, and this difference may have also influenced the intensity of reported symptoms.

Difficulties in falling asleep once or a few times per month was found to be a possible risk factor for generally reduced productivity among young adults with symptoms. The association was weak and probably not clinically relevant, as it does not fulfill the criteria for primary insomnia (52). Furthermore, insomnia, lack of sleep, has been found to be related to absenteeism at work (53). However, no studies, to our knowledge, have shown a direct correlation between difficulties in falling asleep and reduced productivity.

Computer use at school or work and during leisure time as a prospective risk factor for generally reduced productivity

The possibility of developing work-related neck and upper-limb disorders caused by intensive computer use among adults is well-known, for example, in relation to factors such as computer time per day (48, 49, 54–58). The relationship between computer use and musculoskeletal symptoms among young adults has not been extensively studied. However, a prospective study of Thomée et al (59) showed a relationship between upper-extremity symptoms and high versus low computer use among young women. Norman et al (60) found a higher prevalence of neck and upper-extremity symptoms among young computer operators. In our study, leisure-time computer use 8–14 hours/week, versus 1–7 hours/week, was found to be related to generally

reduced productivity. Few studies have been carried out on the relationship between leisure-time factors and musculoskeletal disorders in a young population. However, associations between these factors were found by Niemi et al (61) as hobbies involving static postures of the upper limb (computer use, handiwork, playing the piano) and neck or shoulder pain among 15- to 18-year-old young adults.

Combination of found prospective risk factors

In this study we assessed a combination of the four main risk factors of interest, excluding difficulties in falling asleep one or a few times per month due to probable clinical irrelevance. A dose–response relationship was found, and the relationship was stronger when three or four risk factors were present. The presence of three or four key risk factors gave a higher risk of generally reduced productivity than did the presence of only one or two factors.

Concordance between cross-sectional and prospective risk factors

Having current symptoms in the upper extremities or widespread symptoms in the neck and upper extremities seemed to influence both current and prospective productivity. Perhaps these symptoms remain fairly constant during the year, compared with only neck or shoulder symptoms, which may fluctuate more over time (62). While the duration of computer use during leisure-time may be more of a habit and could explain why there was a prospective relationship to generally reduced productivity. Computer tasks with intensive mouse use may influence current productivity, explaining the cross-sectional association, but not the prospective association. In addition, difficulties in falling asleep several days a week or every day in the last half a year may influence current productivity, but not necessarily long-term productivity. Still, the latency period between the studied exposure factors and generally reduced productivity is unknown.

Gender

Two risk factors were confirmed for the female students in our study group. Current pain or ache in the shoulders, arms, wrists, or hands and widespread symptoms in the upper back or neck and in the shoulders, arms, wrists, or hands. Hagberg et al (30) found gender differences with twice the incidence of reduced productivity among adult women due to symptoms in the neck, shoulders, and forearms or hands than for men. We know from previous studies of adults that women report more musculoskeletal disorders than men (63–65) and even high

school girls have a higher reported number of neck and shoulder symptoms than high school boys (61). In addition, our study group consisted of 60% female students at baseline, and at the 1-year-follow-up 57% of the cases involved female students. Therefore the results were not surprising.

The concept "generally reduced productivity"

In this study generally reduced productivity due to musculoskeletal symptoms was self-reported by young adults. Generally reduced productivity was probably more related to school and leisure-time activities than to work activities, as most of the study group were students. From interviews with young adults with symptoms in the upper extremities (unpublished results by Thomée & Hagberg 2006), perceived generally reduced productivity may appear as less being done or tasks taking a longer time, due to the need for more frequent breaks, concentration difficulties, avoidance of certain tasks, or a negative influence on task speed, for example. In addition, quality and creativity may be affected. Often the activities are carried out, but with a negative effect on symptoms, and also perhaps on leisure-time and physical activities.

Limitations of the study

There are obvious limitations to this study. The response frequency of the vocational school students was low. Analyses of the dropouts have shown that the possible reasons were the vocational school students' lack of interest and their lack of experience with the web-designed questionnaire, despite being experienced computer users. We wanted to study a large group, and the aim was not to compare different types of student groups. Therefore we did not exclude the vocational school students due to their low response frequency. The proportion of the student groups was fairly constant in the subgroups from the study group. However, their exposure may have differed as they may have reasonably belonged to different socioeconomic groups. This possibility should be further explored in forthcoming studies of young adults in larger source populations. Thus the results in this study are probably not representative for young adults in general, but rather can be generalized to young adults in colleges and universities.

Self-reported questionnaires may be insufficient due to recall bias. The questionnaire, including both validated and nonvalidated questions, was tested in a pilot study to prevent recall bias caused by difficulties in understanding the questions or problems in evaluating the duration of different activities. Allen & Bunn (66) found that self-reported measures of productivity performed well in two tests of validity. Stock et al (67)

also established good validity for workers' self-reported physical work demands in a review, for example, the duration of the use of visual display terminals, in contrast to Douwes et al (68), who found an overestimation.

One limitation is the different time periods for the variables in the questionnaire (ie, last week, last month, and last half year). Of course, there may be recall bias in this respect. Koopmanschap et al (6) considered 1 month too long a period when asking about productivity, and a recommendation of a 2-week recall period was made by Stewart et al (69), who found an underestimation of lost productivity with a 4-week recall period. On the other hand, Severens et al (70) found no major differences between 2- or 4-week recall with respect to days absent from work.

Another limitation of this study was the relatively few cases (65 persons) and the number of dropouts (24%) at the 1-year follow-up. Although no major differences were found in the dropout analysis, the results must be interpreted with some caution. For some factors, we could draw no conclusions about a relationship or lack thereof due to the small sample sizes. Furthermore, none of the cases answered the question of "percent of generally reduced productivity" at the follow-up, so we could not assess self-reported generally reduced productivity.

However, the strength of this study is its relatively large cohort and its prospective design. Furthermore, the study group was one that is not frequently studied. Reduced productivity among a young population can be costly for both the community and employers and may cause individual suffering. Unfortunately, in this study, it was not possible to estimate the cost of productivity loss, which has now become an expanding research area (71). It is important to maintain good, health-related quality of life and normal productivity (72) for this group, and several risk factors found in this study may be preventable. Future research could be aimed at validating the concept "generally reduced productivity" with a combined method of a self-rated questionnaire and the measurement of health-related productivity both qualitatively and quantitatively.

Concluding remarks

The main risk factors for generally reduced productivity due to musculoskeletal symptoms among young adults in this study were chronic symptoms in the upper extremities and widespread symptoms in the neck and upper extremities. Moderate computer use during leisure time may also be a risk factor for generally reduced productivity. A combination of risk factors increased the magnitude of prospective risk for generally reduced productivity. It is possible to prevent several of these risk factors.

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