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Association between work stress, physical exercise, and chronic shoulder/neck pain: the HUNT Study

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Abstract

Background: It is well documented that high work stress and low job control is associated with increased risk of shoulder/neck pain while regular physical exercise reduces this risk. However, there is limited knowledge about the combined effect of work stress and physical exercise on risk of chronic pain in shoulders/neck. The first objective of this study was to investigate the role of work stress and physical exercise as individual risk factors for chronic shoulder/neck pain in a large unselected population of women and men. A second objective was to investigate the combined effect of work stress and physical exercise on risk of chronic shoulder/neck pain.

Methods: The Nord-Trøndelag health study (the HUNT Study) was conducted in 1984-1986 (HUNT 1), with follow-up in 1995-1997 (HUNT 2). All women and men who participated in both surveys were included in the present study. After exclusions, the study population consisted of 12,530 women and 16,896 men for the analysis of work stress and job control on risk of chronic shoulder/neck pain, and 8,057 women and 11,028 men for the analysis including physical exercise. Relative risk (RR) of chronic shoulder/neck pain in HUNT 2 associated with work stress, job control, and physical exercise at baseline (HUNT 1) was estimated by a general lineal model.

Results: At follow-up, 4,357 (34,7%) women and 4,470 (26.5%) men reported chronic shoulder/neck pain. Work stress showed a strong dose-response association with risk of chronic shoulder/neck pain (P-trend <.001) for both women and men. Women and men who reported to be exposed to work stress almost all the time had RRs of 1.32 (95% confidence interval [95% CI] 1.11-1.58) and 1.68 (95% CI 1.41-2.00), respectively. The effect of job control on chronic shoulder/neck pain was weak, both among women and men. The different measures of physical exercise (i.e., frequency, duration, and intensity) all showed a moderate inverse dose-response effect on risk of chronic shoulder/neck pain in both women and men (10-20% reduced risk among the most active). The combined analysis showed that individuals who reported high stress levels and who exercised ≥2 sessions per week had a RR of 1.35 (95% CI 1.06-1.72) compared to a RR of 1.64 (95% CI 1.26-2.12) among inactive individuals with similar stress level.

Conclusion: This prospective study indicates that women and men who perceive their work situation as stressful have an increased risk of chronic shoulder/neck pain. There was a moderate inverse relation between physical exercise and risk of chronic shoulder/neck pain for both women and men. Regular physical exercise can, to some extent, compensate for the adverse effect of work stress on risk of chronic shoulder/neck pain.

Introduction

Musculoskeletal pain is one of the main reasons for work disability and long term sick-leave in the western industrialized countries (Tellnes, 1989; Morken et al., 2003; Andersen et al., 2011a), and is commonly associated with stress exposure at work (Lundberg, 1999; Bongers et al., 2002). Musculoskeletal pain is particularly prevalent in neck, shoulders, and low back (Ihlebaek et al., 2002) and is more common in women than men (Bergman et al., 2001; Ihlebaek et al., 2002; Lundberg, 2002).

A frequently cited model to explain the relation between work stress and disease is the demand/decision latitude model (Figure 1), also called the job strain model (Karasek, 1979). According to this model, the risk of disease, associated with high levels of stress, is defined by the interaction between psychological demands and decision latitude (Huang et al., 2002). Ideally, demands and decision latitude should be highly correlated, i.e., an active job situation with high demands and high decision latitude, which is hypothesized to lead to development of new behavioral patterns both on and off the job (Karasek, 1979). However, there are substantial groups of workers with discrepancies between job demands and the decision latitude, e.g., the "high strain" situation (Karasek, 1979). This situation involves high levels of psychological demands and low decision latitude and is hypothesized to place the individual at the greatest risk for undue psychological strain and physical illness. When the body is able to adapt to such demanding situations, it achieves stability through changes in the allostatic systems, i.e., the autonomic nervous system, the hypothalamic-pituitary-adrenal (HPA) axis, and the cardiovascular, metabolic, and immune systems (McEwen, 1998a). However, prolonged stress may lead to over activity of the allostatic systems and increased secretion of stress hormones, referred to as allostatic load (McEwen and Stellar, 1993). Social support has later been added as a third dimension in the demand/decision latitude model to indicate the helpful social interaction with co-workers and supervisors at work (Karasek and Theorell, 1990).

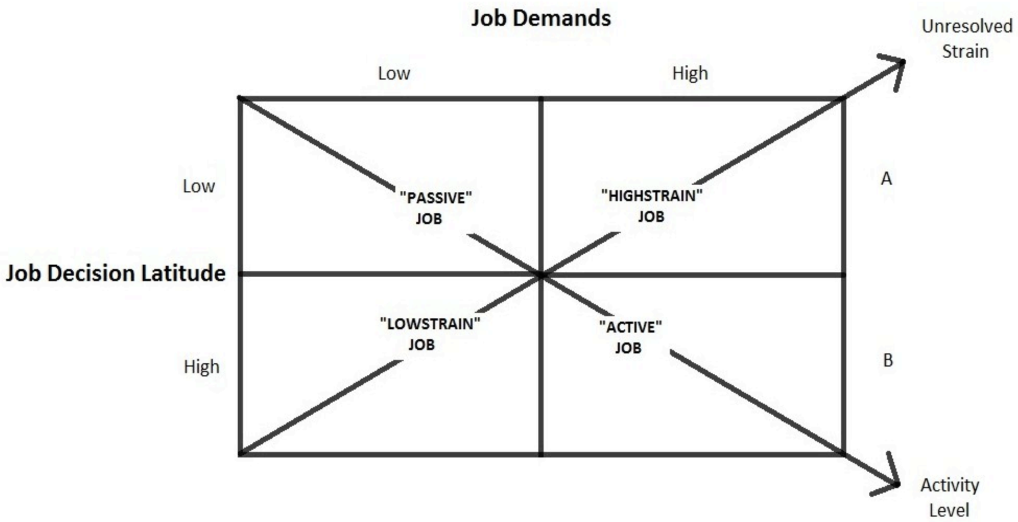

Figure 1. The demand/decision latitude model (modified from Karasek, 1979).

In the literature, monotonous work, high work load, and time pressure are associated with several musculoskeletal disorders (Bongers et al., 1993), while high job stress (Bongers et al., 2002), high psychological demands, and low decision latitude (Norman et al., 2008) are associated with upper extremity problems. Also, evidence has been found for a positive association between neck pain and high physical work demands, low job control, low job satisfaction (Ariëns et al., 2001), and mental demands (Cagnie et al., 2007).

Regular physical exercise is recommended to prevent life-style diseases, such as cardiovascular disease, diabetes, and hypertension (Haskell et al., 2007). Some studies have shown that maintaining regular physical exercise have positive effects on prevention of chronic musculoskeletal pain. A moderate physical activity level at baseline in one study was associated with 53% lower risk of chronic widespread musculoskeletal complaints at follow-up 11 years later (Holth et al., 2008). Sustained sporting activities during one year had favorable effect in preventing shoulder/neck symptoms (van den Heuvel et al., 2005a). Other prospective studies have reported physical activity to have favorable effects on the risk of low back and neck pain, especially in employees with sedentary work (Hildebrandt et al., 2000), as well as more protective than impairing effects on shoulder pain (Miranda et al., 2001). Physical exercise has also been reported to reduce the risk of fibromyalgia in women (Mork et al., 2010) and chronic pain in low back and neck/shoulders in both women and men (Nilsen et al., 2011). These latter studies further reported that physical exercise to some extent could compensate for the adverse effect of high BMI on risk of chronic pain in low back and neck/shoulders as well as fibromyalgia.

Studies investigating the combined effect of work stress and leisure time physical exercise on risk of shoulder/neck pain are limited. Korhonen and co-workers (2003) found that individuals working with video display units with high levels of mental stress and low frequency of physical exercise had an almost sevenfold risk of neck pain compared to individuals with a low stress level and high exercise frequency. However, no large-scale prospective studies have investigated the relation between work stress, shoulder/neck pain, and leisure time physical exercise in the general adult working population.

The main objective of this study was to prospectively investigate the association between work stress, physical exercise, and risk of chronic shoulder/neck pain in a large unselected population of women and men. It is hypothesized that (i) a positive association exist between work stress and risk of chronic shoulder/neck pain, (ii) an inverse association exist between leisure time physical exercise and risk of chronic shoulder/neck pain, and (iii) physical exercise can compensate for the adverse effect of work stress on risk of chronic shoulder/neck pain.

Methods and materials

Study population

In Nord-Trøndelag county, Norway, all inhabitants aged 20 years or older have been invited to participate in a large health survey, the Nord-Trøndelag health study (the HUNT Study). The HUNT Study has been carried out in three waves, the first in 1984-1986 (HUNT 1), the second in 1995-1997 (HUNT 2), and the third in 2006-2008 (HUNT 3). The HUNT Study is one of the largest health studies ever performed and is a collaboration between the HUNT Research Centre (Norwegian University of Science and Technology), the Nord-Trøndelag County Council, and The Norwegian Institute of Public Health.

Of 86,427 eligible participants, 77,216 (89,3%) persons accepted the invitation to participate in HUNT 1. They filled in a questionnaire that were included in the invitation, and underwent a clinical examination with measurement of blood pressure, height, weight, and blood glucose levels. At the examination, the participants were given a second questionnaire to complete and return from home. HUNT 1 consisted mainly of four sub-studies with focus on blood pressure, diabetes, lung diseases, and quality of life. At HUNT 2, 65,215 (70%) persons accepted the invitation to participate. The procedures for evaluation of blood pressure, diabetes and quality of life were similar to those described for HUNT 1. However, both the questionnaire and the clinical examination were more comprehensive in HUNT 2. All participants signed a written consent upon participation in the study. The Regional Committee for Ethics in Medical Research approved the study. More information about the HUNT Study can be found at www.ntnu.edu/hunt.

For the purpose of the present study, all 45,925 persons (24,357 women, 21,568 men) who participated in both HUNT 1 and HUNT 2 were included. We excluded 4,003 women and 3,014 men not working, 5,987 women and 73 men working full time housework, and 31 women and 19 men without information on employment. To obtain a study sample without chronic shoulder/neck pain at baseline (i.e., at the time of HUNT 1), we excluded 1,376 women and 1,350 men who reported that their chronic shoulder/neck pain had lasted for 10 years or more at the time of HUNT 2 as well as 105 women and 103 men with no information on this variable. Also, 111 women and 73 men without information on work stress and 40 women and 11 men with no information on job control were excluded. Due to inconsistencies when answering the questionnaire, 174 women and 29 men still reported to be unemployed and were also excluded. Finally, we excluded 4,473 women and 5,868 men without information on baseline physical exercise. Thus, the prospective analyses of work stress and job control on risk of chronic shoulder/neck pain were based on 12,530 women and 16,896 men, while the analyses including physical exercise were based on 8,057 women and 11,028 men.

Study variables

At follow-up (HUNT 2) the participants were asked if they during the last year had experienced pain and/or stiffness in muscles and joints that lasted for at least 3 consecutive months, with response options "yes" or "no". Answering yes, they were asked to specify the pain-afflicted body area. Participants with complaints in several areas for at least 3 months were asked to specify the area where the complaint had lasted the longest. Subjects answering shoulders, neck, or upper back were included, and in the statistical analysis all three body areas were combined to indicate chronic pain in the shoulders/neck.

In the baseline questionnaire (HUNT 1) the participants answered two questions about their work situation. The question on stress was "Does your work involve a lot of stress and hassles?" and had four response options: "no, not at all", "rarely", "yes, a certain amount", and "yes, almost all the time". For job control the question was "Do you decide how your work is planned?" with four response options: "no, not at all", "a little", "yes, for the most part", and "yes, I decide". In an attempt to match the demand/decision latitude model (Karasek, 1979), the 16 possible combinations of the work stress variable and job control variable were divided into four categories describing the situations in the model. This reduced number of combinations gave larger groups and thereby increased statistical power. In this study the categories in the model were called low stress/high control, low stress/low control, high stress/high control and high stress/low control to better match the study variables.

At baseline (HUNT 1) the participants answered questions on their frequency, intensity and duration of leisure time physical exercise (e.g., walking, skiing, swimming, or doing other form of exercise or sport). On frequency the response options were "never", "<1", "1", "2-3", or "≥4" times per week. No exercise or less than one exercise session per week was counted as inactive, both for frequency, intensity, and duration. If exercising once per week or more, they further answered the question on average exercise intensity with response options "I take it easy, I don't get out of breath or break a sweat", "I push myself until I'm out of breath and break into a sweat", or "I practically exhaust myself". The first response option was counted as low intensity, while the last two were combined and counted as medium/high intensity. Thus, the intensity variable had three options; inactive, low intensity and medium/high intensity. The response options for average duration was "<15 min", "16-30 min", "30-60 min", or ">60 min". The questionnaire is reproducible and has been validated against VO_{2max} in a random sample of men, thereby providing a useful measure of leisure time physical exercise (Kurtze et al., 2008).

Based on information on frequency and duration, a new variable was calculated estimating average hours of physical exercise per week. From the frequency variable, the response option "once per week" was counted as 1 time, "2-3 times per week" was counted as 2.5 times and "≥4 times per week" was counted as 5 times per week. From the duration variable, the response option "<15 min" was counted as 10 min, "15-30 min" was counted as 25 min, "30-60 min" was counted as 45 min and ">60 min" was counted as 75 min per session.

When using frequency in the combined analysis, inactive persons and persons having <1 session of physical exercise per week was defined as inactive, while active persons were divided into groups of 1 session and ≥2 sessions of physical exercise per week. The exercise frequency variable was then combined with the work stress variable, resulting in 12 possible outcome categories.

Statistical analyses

Baseline characteristics of the study population are presented using descriptive statistic (mean, standard deviations, and percentages). For the main analysis, a generalized linear model for the binominal family (log link) was used to estimate the relative risk (RR) of chronic shoulder/neck pain from work stress and job control. Participants without work stress and with high job control were used as reference groups. In the analysis of physical exercise, participants reporting different levels of exercise were compared to a reference group of inactive subjects, i.e., those reported being active less than once a week. For the combined analysis, the reference group consisted of women and men with ≥2 exercise sessions per week reporting no work stress.

The precision of the estimated relative risks (RRs) was assessed by 95% confidence intervals (95% CI). To test for trend across categories of work stress, job control, and physical exercise, the categories were treated as ordinal variables in the regression model. Analysis of work stress, job control, and physical exercise and risk of chronic shoulder/neck pain were stratified by gender. To get larger groups and sufficient statistical power we did not stratify the combined analysis of work stress, physical exercise, and chronic shoulder/neck pain. Potential effect modification between work stress and leisure time physical exercise in the combined analysis was assessed by an interaction test were a product term of these factors were included in the regression model.

The basic models were adjusted for age at baseline, treating the variable as continuous. In the multivariable models for analysis on work stress, job control, and chronic shoulder/neck pain we additionally controlled for possible confounding with BMI (body mass divided by the squared value of the height [kg/m^2], continuous), smoking (never, former, current, unknown), occupation (non-manual, manual, unknown), education (≤9 years, 10-12 years, >12 years, unknown), and physical exercise (inactive, 1 time per week, 2.5 times per week, 5 times per week, unknown). In the multivariable models for analysis on physical exercise and chronic shoulder/neck pain we also controlled for possible confounding with work stress (not at all, rarely, a certain amount, almost all the time). Since the combined analysis was not stratified, we controlled for possible confounding with gender.

All statistical analyses were conducted by use of IBM SPSS Statistics version 19 for Mac.

Results

Table 1 presents the characteristics of the study population according to work stress and job control at baseline, respectively. At follow-up at HUNT 2 (1995-1997), 4,357 (34.7%) women and 4,470 (26.5%) men reported chronic pain in shoulders/neck.

Table 2 shows the age- and multi-adjusted RRs of chronic shoulder/neck pain at follow-up associated with work stress and job control at baseline. There was a clear dose-response effect for work stress, with P-trend <.001 for both women and men. For men who reported a certain amount of work stress and work stress almost all the time, the RRs were 1.51 (95% CI 1.32-1.73) and 1.68 (95% CI 1.41-2.00), respectively. The corresponding RRs among women within the same risk groups were 1.22 (95% CI 1.09-1.36) and 1.32 (95% CI 1.11-1.58), respectively. The effect of job control on risk of shoulder/neck pain was weak, with RRs of 1.11 (95% CI 0.95-1.30) for women and 1.12 (95% CI 0.96-1.32) for men with no job control (i.e., "not at all") compared to women and men with full job control (i.e., "yes, I decide").

Table 1. Baseline characteristics of the study population according to work stress and job control.

	Women				Men			
	Categories of work stress				Categories of work stress			
Characteristics[a]	Not at all	Rarely	A certain amount	Almost all the time	Not at all	Rarely	A certain amount	Almost all the time
Subjects	1,694 (13.5)	4,509 (36.0)	5,662 (45.2)	665 (5.3)	1,428 (8.5)	6,042 (35.7)	8,189 (48.5)	1,237 (7.3)
Mean age (SD)	46.2 (12.7)	41.5 (11.7)	41.0 (11.1)	39.9 (10.6)	48.2 (15.3)	42.0 (12.8)	41.6 (11.3)	40.7 (10.4)
BMI[b], mean (SD)	24.8 (3.9)	24.1 (3.7)	23.8 (3.6)	23.9 (3.7)	25.4 (3.1)	25.0 (2.9)	25.1 (2.9)	25.2 (3.1)
Current smoker	505 (29.8)	1,303 (28.9)	1,593 (28.1)	200 (30.1)	389 (27.2)	1,720 (28.5)	2,349 (28.7)	351 (28.4)
Education >12 years	32 (1.9)	371 (8.2)	919 (16.2)	107 (16.1)	44 (3.1)	499 (8.3)	1,276 (15.6)	230 (18.6)
Manual worker	614 (20.5)	1,217 (40.7)	1,050 (35.1)	111 (3.7)	902 (10.7)	3,581 (42.8)	3,506 (41.8)	406 (4.8)
Physically inactive[c]	478 (28.2)	1,449 (32.1)	1,824 (32.2)	181 (27.2)	537 (37.6)	2,224 (36.8)	2,948 (36.0)	486 (29.3)
	Categories of job control				Categories of job control			
Characteristics[a]	I decide	For the most part	A little	Not at all	I decide	For the most part	A little	Not at all
Subjects	1,155 (9.2)	5,617 (44.8)	4,360 (34.8)	1,398 (11.2)	2,668 (15.8)	8,735 (51.7)	4,560 (27.0)	933 (5.5)
Mean age (SD)	45.7 (12.7)	42.0 (11.6)	40.3 (11.0)	43.0 (12.0)	45.5 (13.0)	42.4 (12.0)	40.2 (12.0)	41.7 (13.0)
BMI[b], mean (SD)	24.8 (4.1)	24.1 (3.6)	23.8 (3.6)	24.2 (3.7)	25.4 (3.1)	25.1 (2.9)	25.0 (3.0)	25.3 (3.2)
Current smoker	316 (27.4)	1,522 (27.1)	1,296 (29.7)	467 (33.4)	695 (26.0)	2,356 (27.0)	1,439 (31.6)	319 (34.2)
Education >12 years	84 (7.3)	772 (13.7)	523 (12.0)	50 (3.6)	215 (8.1)	1,349 (15.4)	465 (10.2)	20 (2.1)
Manual worker	395 (13.2)	1,424 (47.6)	838 (28.0)	335 (11.2)	1,489 (17.7)	3,907 (46.5)	2,433 (29.1)	566 (6.7)
Physically inactive[c]	371 (32.1)	1,702 (30.3)	1,390 (31.9)	469 (33.5)	1,061 (39.8)	3,072 (35.2)	1,687 (37.0)	375 (40.2)

Abbreviation: SD, standard deviation. BMI, body mass index.

[a]Exept when indicated otherwise, values are number (%).

[b]Weight (kg)/height (m)^2.

[c]No activity or <1 exercise session per week.

Table 2. Relative risk (RR) of chronic shoulder/neck pain among women and men at 11-year follow-up associated with work stress and job control at baseline.

	No. of persons	No. of cases	Age-adjusted RR[a]	Multi-adjusted RR[b]	95% CI	P-trend
			Women			
Work stress						
Not at all	1,694	546	1.0	1.0	(Ref.)	
Rarely	4,509	1,458	1.00	1.04	(0.92-1.64)	
A certain amount	5,662	2,084	1.14	1.22	(1.09-1.36)	
Almost all the time	665	269	1.26	1.32	(1.11-1.58)	<.001
Job control						
Yes, I decide	1,155	386	1.0	1.0	(Ref.)	
Yes, for the most part	5,617	1,853	0.99	1.02	(0.89-1.16)	
A little	4,360	1,592	1.10	1.12	(0.99-1.28)	
Not at all	1,398	526	1.13	1.11	(0.95-1.30)	.015
			Men			
Work stress						
Not at all	1,428	294	1.0	1.0	(Ref.)	
Rarely	6,042	1,480	1.21	1.25	(1.08-1.43)	
A certain amount	8,189	2,316	1.40	1.51	(1.32-1.73)	
Almost all the time	1,237	380	1.52	1.68	(1.41-2.00)	<.001
Job control						
Yes, I decide	2,668	676	1.0	1.0	(Ref.)	
Yes, for the most part	8,735	2,234	1.01	1.05	(0.95-1.15)	
A little	4,560	1,279	1.12	1.11	(1.00-1.24)	
Not at all	933	281	1.20	1.12	(0.96-1.32)	.030

[a]Continuous.
[b]Adjusted for age (continuous), BMI (continuous), smoking (never, former, current, unknown), occupation (non-manual, manual, unknown), education (≤9 years, 10-12 years, >12 years, unknown), physical exercise (inactive, 1 time per week, 2.5 times per week, 5 times per week, unknown).

Table 3 shows the RR of chronic shoulder/neck pain associated with the combined effect of work stress and job control at baseline. For women who reported high stress/low control at work the RR was 1.24 (95% CI 1.14-1.36), while men reporting high stress/low control had RR of 1.32 (95% CI 1.20-1.44) compared to the reference group with low stress/high control. Moreover, high stress and high control were also associated with increased risk of chronic shoulder/neck pain with RR 1.17 (95% CI 1.06-1.29) and 1.23 (95% CI 1.13-1.34) among women and men, respectively.

Overall, the different measurements of physical exercise were associated with similar preventive effect on risk of chronic shoulder/neck pain (Table 4). P-value for trend showed a moderate dose-response effect on the risk of chronic shoulder/neck pain in all categories of exercise but the effect of hours of physical exercise per week was somewhat larger in women with ≥3 hours of exercise per week (RR 0.79, 95% CI 0.64-0.98) than in men exercising ≥3 hours per week (RR 0.87, 95% CI 0.73-1.05). Medium to high intensity was associated with a lower risk of chronic shoulder/neck pain in both women and men with adjusted RRs of 0.88 (95% CI 0.78-0.99) and 0.88 (95% CI 0.80-0.97), respectively.

Table 3. Relative risk (RR) of chronic shoulder/neck pain among women and men at 11-year follow-up associated with the combined effect of work stress and job control at baseline.

	No. of persons	No. of cases	Age-adjusted RR[a]	Multi-adjusted[b] RR	95% CI
Women					
Low stress, high control	4,229	1,344	1.0	1.0	(Ref.)
Low stress, low control	1,974	660	1.05	1.05	(0.94-1.17)
High stress, high control	2,543	895	1.11	1.17	(1.06-1.29)
High stress, low control	3,784	1,458	1.21	1.24	(1.14-1.36)
Men					
Low stress, high control	5,610	1,334	1.0	1.0	(Ref.)
Low stress, low control	1,860	440	1.00	0.97	(0.86-1.09)
High stress, high control	5,793	1,576	1.15	1.23	(1.13-1.34)
High stress, low control	3,633	1,120	1.31	1.32	(1.20-1.44)

[a]Continuous.
[b]Adjusted for age (continuous), BMI (contiuous), smoking (never, former, current, unknown), occupation (non-manual, manual, unknown), education (≤9 years, 10-12 years, >12 years, unknown) physical exercise frequency (inactive, 1 time per week, 2.5 times per week, 5 times per week, unknown).

Results from the combined analysis of work stress and physical exercise level on risk of chronic shoulder/neck pain is shown in Table 5. Overall, individuals who reported ≥2 exercise sessions per week had a 13-29% reduced risk of chronic shoulder/neck pain compared to inactive individuals with similar work stress exposure. Although there was no interaction (P-value .902) between exercise level and chronic shoulder/neck pain it was observed that inactive persons with high stress level had a RR of 1.64 (95% CI 1.26-2.12) while individuals who exercised ≥2 times per week, and who also had high stress level, had a RR of 1.35 (95% CI 1.06-1.72).

In addition to exercise frequency, we also analyzed the combined effect of work stress and exercise intensity (Table 6). There was no interaction (P-value .560) between exercise intensity and work stress, but we observed that inactive persons with high stress had a RR of 1.52 (95% CI 1.16-2.00) while persons who exercised with medium/high intensity with similar stress exposure had a RR of 1.31 (95% CI 1.03-1.66).

Table 4. Relative risk (RR) of chronic shoulder/neck pain at 11-year follow-up associated with physical exercise level at baseline.

	No. of persons	No. of cases	Age-adjusted RR[a]	Multi-adjusted RR[b]	95% CI	P-trend
			Women			
Exercise per week, hours						
Inactive[c]	1,700	669	1.0	1.0	(Ref.)	
<1	2,928	1,007	0.87	0.91	(0.81-1.02)	
1-1.9	2,336	753	0.82	0.88	(0.78-1.00)	
2-2.9	635	224	0.90	0.95	(0.79-1.13)	
≥3	458	133	0.74	0.79	(0.64-0.98)	.043
Exercise sessions per week, no.						
Inactive[c]	1,700	669	1.0	1.0	(Ref.)	
1	3,041	1,038	0.87	0.91	(0.81-1.02)	
2-3	2,358	776	0.84	0.90	(0.79-1.02)	
≥4	958	303	0.81	0.85	(0.73-1.00)	.045
Exercise intensity						
Inactive[c]	1,700	669	1.0	1.0	(Ref.)	
Low	3,348	1,140	0.87	0.91	(0.81-1.02)	
Medium/high	3,009	977	0.82	0.88	(0.78-0.99)	.038
			Men			
Exercise per week, hours						
Inactive[c]	3,062	885	1.0	1.0	(Ref.)	
<1	3,082	786	0.88	0.92	(0.82-1.03)	
1-1.9	2,961	695	0.81	0.88	(0.78-0.98)	
2-2.9	1,138	261	0.80	0.86	(0.73-1.00)	
≥3	785	180	0.79	0.87	(0.73-1.05)	.018
Exercise sessions per week						
Inactive[c]	3,062	885	1.0	1.0	(Ref.)	
1	3,679	926	0.87	0.91	(0.82-1.01)	
2-3	3,169	735	0.80	0.88	(0.78-0.98)	
≥4	1,118	261	0.80	0.88	(0.75-1.03)	.023
Exercise intensity						
Inactive[c]	3,062	885	1.0	1.0	(Ref.)	
Low	2,459	631	0.88	0.91	(0.81-1.03)	
Medium/high	5,507	1,291	0.81	0.88	(0.80-0.97)	.014

[a]Continuous.
[b]Adjusted for age (continuous), BMI (continuous), smoking (never, former, current, unknown), occupation (non-manual, manual, unknown), stress (not at all, rarely, a certain amount, almost all the time).
[c]No activity or <1 exercise session per week.

Table 5. Relative risk (RR) for chronic shoulder/neck pain at 11-year follow-up associated with the combined effect of work stress and physical exercise at baseline.

	≥2 sessions per week			1 session per week			Inactive[a]		
	Age-adjusted RR[b]	Multi-adjusted RR[c]	95% CI	Age-adjusted RR[b]	Multi-adjusted RR[c]	95% CI	Age-adjusted RR[b]	Multi-adjusted RR[c]	95% CI
Stress level									
Not at all	1.0	1.0	(Ref.)	1.04	1.01	(0.80-1.27)	1.19	1.19	(0.95-1.48)
Rarely	1.01	1.10	(0.93-1.31)	1.13	1.18	(1.00-1.40)	1.23	1.27	(1.07-1.52)
A certain amount	1.19	1.35	(1.15-1.59)	1.22	1.34	(1.13-1.58)	1.40	1.48	(1.25-1.75)
Almost all the time	1.19	1.35	(1.06-1.72)	1.37	1.57	(1.23-2.01)	1.47	1.64	(1.26-2.12)

[a]No activity or <1 exercise session per week.
[b]Continuous.
[c]Adjusted for gender, age (continuous), BMI (continuous), smoking (never, former, current, unknown), occupation (non-manual, manual, unknown).

Table 6. Relative risk (RR) for chronic shoulder/neck pain at 11-year follow-up associated with the combined effect of work stress and physical exercise intensity at baseline.

	Medium/ high intensity			Low intensity			Inactive[a]		
	Age-adjusted RR[b]	Multi-adjusted RR[c]	95% CI	Age-adjusted RR[b]	Multi-adjusted RR[c]	95% CI	Age-adjusted RR[b]	Multi-adjusted RR[c]	95% CI
Stress level									
Not at all	1.0	1.0	(Ref.)	0.96	0.89	(0.71-1.12)	1.15	1.11	(0.87-1.40)
Rarely	0.92	1.01	(0.83-1.21)	1.18	1.13	(0.94-1.37)	1.18	1.19	(0.98-1.44)
A certain amount	1.10	1.25	(1.04-1.50)	1.23	1.25	(1.04-1.50)	1.34	1.38	(1.14-1.66)
Almost all the time	1.13	1.31	(1.03-1.66)	1.39	1.43	(1.09-1.88)	1.41	1.52	(1.16-2.00)

[a]No activity or <1 exercise session per week.
[b]Continuous.
[c]Adjusted for gender, age (continuous), BMI (continuous), smoking (never, former, current, unknown), occupation (non-manual, manual, unknown).

Discussion

This longitudinal population based study indicates that a strong dose-response association exists between work stress and future risk of chronic shoulder/neck pain in both women and men. The independent effect of job control on risk of chronic shoulder/neck pain was rather weak. Overall, all measures of leisure time physical exercise (i.e., frequency, intensity, and duration) were associated with a reduced risk of chronic shoulder/neck pain both among women and men. Moreover, combined analyses showed that physical exercise to some extent could compensate for the adverse effect of work stress on risk of chronic shoulder/neck pain.

The demand/decision latitude model was used as departure point for the current study. However, there are some dissimilarity between this model and our data that should be kept in mind in the interpretation of our findings. The data forming the base for Karaseks model and the data used in the present study were both based on cohorts that include different types of occupations. However, the questionnaires used by Karasek (1979) were more comprehensive than the questionnaires used in HUNT 1. In HUNT 1, participants were not asked directly about job demands and job decision latitude. Instead they answered one general question on how stressful they perceive their work situation and one question on job control, with four response options on each question. Thus, the job situation categories used in our analysis are based on combinations of work stress and job control, and the results cannot be directly compared to the demand/decision latitude model (Karasek, 1979). Nevertheless, the basic idea of an association between work stress exposure, job control, and long-term health outcome is similar.

Earlier studies have not investigated the prospective association between work stress and shoulder/neck pain but have, however, investigated different work-related psychological and/or psychosocial work conditions, which are all different factors contributing to perceived work stress. Associations have been shown between risk of neck/shoulder symptoms and different work-related psychological exposures such as high job demands, empowering leadership, role conflict, time pressure, low job control, and lack of social support (Bongers et al., 2002; van den Heuvel et al., 2005b; Christensen and Knardahl, 2010). Since the HUNT data do not allow assessment of different psychological exposures, the participants in the present study were classified into broad categories of work stress (i.e., “no, not at all”, “rarely”, “yes, a certain amount”, and “yes, all the time”) instead of groups of more specific work stress exposures. The use of different variables in the abovementioned studies makes it difficult to accurately compare the results of these studies to our results. Nevertheless, the overall results show that different work related stress factors are associated with risk of neck/shoulder pain. Thus, the strong association between work stress and increased risk of chronic shoulder/neck pain in our study is in line with previous findings.

The effect of job control as an independent risk factor for chronic shoulder/neck pain was found to be weak in the present study. Previous studies have reported contrasting findings regarding the association between job control and risk of neck and/or shoulder pain. One prospective study found no evidence of an association between low decision latitude and risk of neck and shoulder pain, in neither women nor men (Östergren et al., 2005). The opposite result was found in another prospective study where low levels of job control were associated with increased risk of shoulder pain in men and, to a lesser extent, in women (Leclerc et al., 2004). The participants in the latter study had mainly occupations requiring repetitive work, and with such biomechanical constraints in addition to psychological demands it may be more difficult to control how you do your work. Karasek argues that low decision latitude is the primary work-related risk factor for health problems, and that a demanding job results in elevated risk only in interaction with low control (Karasek and Theorell, 1990). In the study by Östergren and co-workers (2005), the combination of high psychosocial work demands and low decision latitude was associated with an increased risk of neck and shoulder pain in women. Since work stress in our study showed an independently strong effect while the independent effect of job control was weak, the effect in the combined analysis is mainly from work stress. The difference from findings in previous studies may be explained from the more general classification of work stress and job control as well as the inclusion of a broad range of different occupations.

The physiological mechanisms behind chronic shoulder/neck pain are not well understood but stress appears to be an important risk factor. When exposed to a stressor, the most common allostatic systems activated is the sympathetic nervous system and the HPA axis (McEwen, 1998a). For adequate function of these systems it is necessary to have the opportunity for rest and recovery (McEwen, 1998b). When the allostatic systems are turned on and off efficiently and not too frequently, the body is able to cope and adapt to new environmental challenges. In the modern society, the allostatic systems are mainly activated by various psychosocial conditions such as stress exposure at work (Lundberg, 2002). Repeated and prolonged exposure to stress may result in excessive wear and tear on the allostatic systems that become less able to shut themselves off after stress exposure (McEwen, 1998a), i.e., resulting in allostatic load (McEwen and Stellar, 1993). Activation of the sympathetic nervous system also prepares the body to fight or flight in response to a physical threat (Cannon, 1914), and this activation is associated with an elevated pain threshold (Maier et al., 1982). Based on this, the possible role of psychosocial factors at work on pain perception has been investigated (Theorell et al., 1993). Theorell and co-workers (1993) reported that before a psychological stress test, individuals with high self-reported psychological demands at work had elevated pain thresholds. It is argued that those with habitually high levels of self-reported demands at work may be in a long-lasting state of fight or flight activation, and that these individuals may not react efficiently to bodily warning signals of, e.g., pain and tissue overexertion. This may explain why persons who experience high levels of stress run an elevated risk of developing chronic symptoms from the musculoskeletal system.

Concerning the neurophysiological mechanisms, there seem to be general agreement to what happens when the body is exposed to an injury. Since pain is a hallmark of inflammatory processes (Haack et al., 2007), the same mechanisms are suggested to apply for musculoskeletal pain (Maier and Watkins, 1998). The adaptive behavior and physiological changes in the body caused by an injury are related to an activation of the immune system. This reaction is initiated by the release of pro-inflammatory cytokines such as interleukin-1 (IL-1), interleukin-6 (IL6), and tumor necrosis factor alpha (TNF-α), which facilitate an inflammatory reaction and attract other immune cells that participates in healing (Maier and Watkins, 1998). Physical and physiological stressors provoking fight or flight reactions are argued to activate the same neural circuits as an injury, leading to increased levels of circulating pro-inflammatory cytokines (Maier and Watkins, 1998). Increased levels of pro-inflammatory cytokines are correlated with increased pain sensitivity (Koch et al., 2007). Elevated levels of IL-6 has been reported to be associated with increased pain ratings in response to prolonged sleep restriction (Haack et al., 2007) but whether the effect of exercise on pain is similar to the effect of sufficient sleep is uncertain. However, exercise is suggested to have an anti-inflammatory effect (Das, 2004), which may be one explanation to the reduced risk of chronic shoulder/neck pain from physical exercise found in the present study. Initially, it is the enhanced production of pro-inflammatory cytokines that stimulates increased generation of anti-inflammatory cytokines. Exercise causes release of these pro-inflammatory cytokines, and anti-inflammatory cytokines are produced to restrict the magnitude and duration of the inflammatory response to exercise. In other words, exercise is suggested to have the ability to suppress the production of inflammatory markers and enhance the anti-inflammatory indices (Das, 2004), thereby reducing pain.

Although there was no interaction between exercise level and chronic shoulder/neck pain in the current study, the compensating effect of physical exercise on chronic shoulder/neck pain found in persons with high stress level may be explained from the abovementioned suggestions. An interaction between mental stress and physical exercise on neck pain among office employees working with video display units has been reported earlier (Korhonen et al., 2003). Individuals with a high level of mental stress and low frequency of physical exercise had an almost sevenfold risk of neck pain compared to individuals with low stress level and high exercise frequency. This was a selected sample of workers who spent their workday in front of the computer with exposure to some mechanical load in addition to mental stress, and therefore, the results cannot be directly compared to the current study focusing on the general working population. Thus, to the best of our knowledge, the present study is the first longitudinal study to report a compensatory effect from physical exercise on chronic shoulder/neck pain in the general adult working population.

The present study investigated the protective effect of physical exercise on risk of chronic shoulder/neck pain, and overall, we found a moderate dose-response effect for all the different measurements of exercise. Previous studies based on HUNT data have reported physical exercise to reduce the risk of fibromyalgia in women (Mork et al., 2010) and chronic pain in low back and neck/shoulders in both women and men (Nilsen et al., 2011). Although these studies, as well as the current study, have long follow-up of 11 years, the results from physical exercise are based on baseline information only. Therefore, we do not know whether exercise levels has changed during the follow-up period and affected the development of pain.

Considering long-term effects of physical exercise used in treatment of chronic musculoskeletal pain, the existing literature indicate that exercise have beneficial effects. Strong effects from specific strength training locally for pain-affected muscles in neck/shoulders have been reported, both immediately after a 10 week intervention period, as well as 10 weeks after the intervention (Andersen et al., 2008). It may therefore seem as a paradox that physical exercise in our study only shows a moderate effect on risk of chronic shoulder/neck pain, while exercise used in treatment of chronic shoulder/neck pain shows strong effects. This difference is likely explained by the questions about exercise used in HUNT 1. The participants were not asked to define what type of exercise they did, e.g., whether they did strength training or endurance training. Hence, the protective effect of physical exercise could possibly have been stronger if we had these data and performed the analyses according to type of exercise. Nevertheless, several studies have investigated different forms of exercise in treatment of chronic shoulder/neck pain, with some forms showing better effects than others. A review reported moderate evidence supporting the effectiveness of long-term dynamic and isometric resistance exercises of the neck and shoulder muscles for chronic or frequent neck disorders and no support for the long term effect of very low intensity exercises on chronic neck pain (Ylinen, 2007). Strength training, endurance training, and co-ordination training has been associated with similar improvement in symptoms of work-related neck-shoulder pain in women (Waling et al., 2000). However, stretching and aerobic exercise alone has proved to be a much less effective than strength training and dynamic endurance training to reduce chronic neck symptoms and disability in women (Ylinen et al., 2003). Even as little as 2 to 12 minutes of daily progressive resistance training has shown clinically relevant reductions of neck/shoulder pain (Andersen et al., 2011b). Future epidemiological studies should preferable include more detailed information about type of exercise to enable a more thorough assessment of the preventive effect of physical exercise on risk of chronic shoulder/neck pain.

In the current study, high exercise intensity was associated with a moderate risk-reducing effect in both women and men. Although our combined analysis did not show an interaction between exercise intensity and work stress, it was observed that inactive persons with high work stress had higher risk of chronic shoulder/neck pain than persons in the same stress group exercising with medium/high intensity. In summary, no firm conclusion can be drawn concerning what type of exercise should be recommended to prevent chronic shoulder/neck pain, but it seems that exercise with higher intensity may be more beneficial than low intensity exercise.

The strengths of the current study are the prospective design and the large unselected population representing a broad range of different occupations. The study also has some limitations. By using a questionnaire, individual interpretations of the questions and response options may lead to misclassification of shoulder/neck pain and physical exercise. Also, the HUNT data does not include information on type of exercise; hence, the different exercise types and the possible importance in preventing development of chronic shoulder/neck pain could not be assessed. The HUNT data contains broad variety of variables that gives the opportunity to control for several factors. Thus, possible confounding with other factors, such as psychological well-being, number of children at home for women and other demands outside work may be of importance but were not included in our analysis.

Conclusion

This prospective study indicates that women and men who perceive their work situation as stressful have an increased risk of chronic shoulder/neck pain. Low job control was weakly associated with higher risk of chronic shoulder/neck pain. There was a moderate inverse relation between physical exercise and risk of chronic shoulder/neck pain for both women and men. Regular physical exercise can, to some extent, compensate for the adverse effect of work stress on risk of chronic shoulder/neck pain.

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