EVIDENCE BASED PUBLIC HEALTH POLICY AND PRACTICE

Incidence of shoulder and neck pain in a working population: effect modification between mechanical and psychosocial exposures at work? Results from a one year follow up of the Malmö shoulder and neck study cohort

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Study objective: To assess the impact of mechanical exposure and work related psychosocial factors on shoulder and neck pain.
Design: A prospective cohort study.
Participants: 4919 randomly chosen, vocationally active men and women ages 45–65 residing in a Swedish city. Neck and shoulder pain were determined by the standardised Nordic questionnaire. Mechanical exposure was assessed by an index based on 11 items designed and evaluated for shoulder and neck disorders. Work related psychosocial factors were measured by the Karasek and Theorell demand-control instrument.
Main results: High mechanical exposure was associated with heightened risk for shoulder and neck pain among men and women during follow up. Age adjusted odds ratios (OR) were 2.17 (95% confidence intervals (CI): 1.65, 2.85) and 1.59 (95% CI: 1.22, 2.06), respectively. In women, job strain (high psychological job demands and low job decision latitude) correlated with heightened risk (OR = 1.73, 95% CI: 1.29, 2.31). These risk estimates remained statistically significant when controlled for high mechanical exposure regarding job strain (and vice versa), and for sociodemographic factors. Testing for effect modification between high mechanical exposure and job strain showed them acting synergistically only in women.
Conclusion: Job related mechanical exposure in both sexes, and psychosocial factors in women, seem independently of each other to play a part for development of shoulder and neck pain in vocationally active people. The effect of psychosocial factors was more prominent in women, which could be the result of biological factors as well as gender issues. These results suggest that interventions aiming at reducing the occurrence of shoulder and neck pain should include both mechanical and psychosocial factors.

Work related musculoskeletal disorders and complaints constitute an important health problem in many industrialised countries, as they account for a large number of working days lost and considerable workers compensation and disability payments.[1–3] For a long time, low back pain has been the dominant problem. However, pain from the shoulder and neck region now seems to occur more frequently.[4 5] The prevalence of shoulder-neck symptoms is highest in the 45–65 year age bracket, as well as among women, manual workers, and certain ethnic groups.[6]

However, its aetiology is still incompletely understood. Mechanical exposure at work and psychosocial conditions within and without the workplace, in addition to lifestyle and individual variables (age, previous symptoms, etc) are frequently discussed as causal factors in the literature.[7–11]

Shoulder and neck symptoms have been linked to jobs with highly repetitive work, static work, and work above shoulder level.[12–17] However, mechanical exposure explains only part of these complaints. The role of psychosocial factors in the workplace has therefore received increasing attention. On the job pressure, monotonous work, and a high perceived workload have also been associated with musculoskeletal symptoms just as much as working situations characterised by high psychological demands, low decision latitude, and low social support.[1 9 11 14 17]

Hence, an aetiological model explaining shoulder and neck symptoms could be based on the assumption of an interaction between mechanical and psychosocial factors at work.[1 9 18] There is, however, a need to clarify the interplay between these risk factors.

A number of shortcomings in previous research into the causes of back and neck pain have been recognised.[1 9 17] Firstly, few studies have separated low back and neck pain, which would seem to be an important distinction because of potentially different epidemiological patterns and assumedly different risk factors.[19] Secondly, studies regarding the role of psychosocial risk factors in these outcomes seldom have adequately controlled their risk estimates with respect to potential confounding from mechanical exposure.[17]

Moreover, few studies have been performed on populations having a sufficient variety of both mechanical and psychosocial exposures.[17 20] The presumed high correlation between the two risk factors cited can only be weighed adequately in a large study sample in which diverse job tasks are represented.

Abbreviations: MSNS, Malmö shoulder and neck study; MDCS, Malmö diet and cancer study; MEI, mechanical exposure index; SNQ, standardised Nordic questionnaire

† Deceased in June 2000.

Table 1 Demographic and socioeconomic characteristics of the Malmö shoulder and neck study cohort (n = 4919)

	Men		Women	
Age	**Number**	**%**	**Number**	**%**
45–49	506	19.1	468	20.6
50–54	947	35.7	851	37.5
55–59	781	29.5	643	28.3
60–64	415	15.7	308	13.6
Missing data	0	0	0	0
Totals	2649	100	2270	100
Country of origin				
Sweden	2410	91.0	2094	92.2
Other	238	9.0	176	7.8
Missing data	1	0.0	0	0
Marital status				
Married	1944	73.4	1372	60.4
Unmarried	290	10.9	240	10.6
Divorced	363	13.7	536	23.6
Widowed	52	2.0	121	5.3
Missing data	0	0	1	0.0
Educational level				
>12 years	705	26.6	689	30.4
10–12 years	953	36.0	918	40.4
⩾9 years	990	37.4	662	29.2
Missing data	1	0.0	1	0.0
Occupational class				
High level non-manual	671	25.3	357	15.7
Middle level non-manual	593	22.4	496	21.9
Low level non-manual	408	15.4	766	33.7
Skilled manual	397	15.0	125	5.5
Unskilled manual	330	12.5	472	20.8
Missing data	250	9.4	54	2.4
Pains from other regions				
No	2280	86.1	1848	81.4
Yes	369	13.9	419	18.5
Missing data	0	0	3	0.1

Participants in the Malmö shoulder and neck study 45–64 years old, working at least 30 hours per week who were free from neck and shoulder pain at baseline.

Finally, few attempts have been made to quantify the multidimensionality of mechanical exposure.[21–24] Nor have such measures been used in relation to psychosocial ones—particularly not in a prospective study design.

This study has attempted to address all the mentioned issues. Based on a large general population cohort, its intentions are to analyse the importance of both mechanical and psychosocial exposures in the workplace on the incidence of shoulder-neck complaints, and evaluate the possible effect modification between these two exposures.

METHODS

Design and population

The Malmö shoulder and neck study (MSNS) was designed as a prospective questionnaire based study with a follow up period of one year. The cohort is a subset of the larger Malmö diet and cancer study (MDCS) cohort, which consists of all men and women in the city of Malmö (240 000 inhabitants) born between 1926 and 1945—that is, those between 45 to 65 years of age in 1991, when the cohort was defined (n = 53 494).[25]

The MSNS cohort consists of every participant who completed the baseline examination of the MDCS between February 1992 and December 1994 (n = 14 555), the period when items assessing shoulder and neck pain were included in the questionnaire. People were selected by random from the population register and either received a personal invitation (74.0%), or were recruited by a media campaign (26.0%). Possible selection bias of the MSNS sample was estimated by comparing sociodemographic data from the municipal statistics office regarding the complete age cohort in February 1994. This analysis supported the assumption that the MSNS cohort is reasonably representative of the corresponding general age cohorts in Malmö.[26]

The baseline questionnaire inquired into musculoskeletal symptoms, marital status, ethnicity, level of education, occupational status, lifestyle factors, mechanical exposures, and psychosocial factors at work. The participants were instructed to answer questions regarding work related exposure, as referred to their present work situation.

A follow up was performed after about one year, when a questionnaire was mailed to all 14 555 participants, of whom 86.6% responded (12 607). The mean follow up time was 403.1 days (standard deviation (SD) 48.9).

These analyses are based on subjects younger than the retirement age of 65 at baseline who had been vocationally active for at least 30 hours per week during the follow up who had not had shoulder or neck pain (defined in the same way as in the cases of this study) for 12 months before the baseline assessment (n = 4919).

Outcome variables

A modified version of the standardised Nordic questionnaire (SNQ) for the analysis of musculoskeletal symptoms was used to assess shoulder and neck pain at baseline and at follow up.[27] The original five point category scale that sought to establish the frequency of the subject's complaint was modified to focus on the subject's temporal assessment of occurrences as ''never'', ''once or twice'', ''sometimes'', ''often'', or ''all the time''. As in the original version of the SNQ, topographical areas were specified through the presentation of drawings indicating the areas referred to in the questionnaire. Separate questions solicited complaints regarding the neck, shoulders, low back, and arms/hands. The five rungs of the SNQ items were dichotomised, and

Table 2 Cumulative incidence and age adjusted odds ratios regarding neck pain in different sociodemographic groups among occupationally active men and women between ages 45–64 in the Malmö shoulder and neck study

	Men				Women			
	Number	Number of cases	One year cumulative incidence (%)	Odds ratio (95% CI)	Number	Number of cases	One year cumulative incidence (%)	Odds ratio (95% CI)
Age								
45–49	506	26	5.1	1.0 (reference)	468	50	10.7	1.0(reference)
50–54	947	58	6.1	1.20 (0.75, 1.94)	851	67	7.9	0.71 (0.49, 1.05)
55–59	781	49	6.3	1.24 (0.76, 2.02)	643	45	7.0	0.63 (0.41, 0.96)
60–64	415	25	6.0	1.18 (0.67, 2.08)	308	21	6.8	0.61 (0.36, 1.04)
Totals	2649	158	6.0		2270	183	8.1	
Country of origin								
Sweden	2410	137	5.7	1.0 (reference)	2094	160	7.6	1.0 (reference)
Other	238	21	8.8	1.61 (0.99, 2.60)*	176	23	13.1	1.83 (1.15, 2.92)*
Marital status								
Married	1944	116	6.0	1.0 (reference)	1372	107	7.8	1.0 (reference)
Unmarried	290	14	4.8	0.79 (0.45, 1.41)*	240	14	5.8	0.70 (0.39, 1.25)*
Divorced	363	20	5.5	0.92 (0.56, 1.49)*	536	55	10.3	1.35 (0.96, 1.90)*
Widowed	52	8	15.4	2.88 (1.32, 6.27)*	121	7	5.8	0.80 (0.36, 1.77)*
Educational level								
>12 years	705	27	3.8	1.0 (reference)	689	51	7.4	1.0 (reference)
10–12 years	953	47	4.9	1.30 (0.80, 2.11)*	918	68	7.4	1.03 (0.71, 1.50)
<9 years	990	83	8.4	2.31 (1.48, 3.61)*	662	64	9.7	1.44 (0.98, 2.13)*
Occupational class								
High level non-manual	671	34	5.1	1.0 (reference)	357	30	8.4	1.0 (reference)
Middle level non-manual	593	27	4.6	0.89 (0.53, 1.49)*	496	28	5.6	0.67 (0.39, 1.14)*
Low level non-manual	408	19	4.7	0.92 (0.52, 1.63)*	766	71	9.3	1.15 (0.74, 1.80)*
Skilled manual	397	39	9.8	2.04 (1.27, 3.29)*	125	6	4.8	0.57 (0.23, 1.42)*
Unskilled manual	330	25	7.6	1.53 (0.90, 2.61)*	472	45	9.5	1.20 (0.74, 1.95)*
Pain from other regions								
No	2280	103	4.5	1.0 (reference)	1848	118	6.4	1.0 (reference)
Yes	369	55	14.9	3.71 (2.62, 5.25)*	419	65	15.5	2.73 (1.97, 3.77)*

*Adjusted for age.

shoulder and neck pain were defined in terms of the two highest rungs, namely, as complaints reportedly experienced ''often'' or ''all the time'' during the past 12 months.

Exposure variables

The instrument for assessing the mechanical exposure index (MEI) was constructed on a framework based upon mechanistic theories.[24] The MEI is extracted from 24 of 33 questions regarding occupational mechanical exposure, as has been developed and used in the Stockholm MUSIC I study.[28] The response scale was revised to one of three points, the verbal quantifiers being ''hardly anything/not at all'', ''somewhat'', and ''a great deal''.[18] Thus, the item scale relates to the subjective perception of the exposure quantity, and does not consider estimation of specific duration or frequency aspects.

The index consists of 11 of 24 items mainly assessing body posture. It was shown to have a much higher validity than job titles. The internal consistency of the index was very high, with a Chronbach's α of 0.83. Two week test-retest stability expressed as weighted κ value was 0.78; 12 month stability was 0.83.[24] The MEI sum thus ranged from 11 to 33. Those with a score of 16 or more were considered to be exposed to high work related mechanical exposure (upper quartile).

Psychosocial work exposure was assessed by an instrument developed by Karasek and Theorell measuring a combination of psychological job demands and job decision latitude.[29] Job demands and decision latitude were analysed by means of five and six items, respectively, to which the participants replied on a scale with four rungs. The single items were weighted according to a system suggested by Karasek.[29] Those with a total score of 34 or above on the job demands scale (ranging from 13 to 52) were considered to be exposed to high job demands. Those with a score of 56 or less on the decision latitude scale (a range of 18 to 72), were considered to be exposed to low decision latitude. The combination of high psychological demands and low decision latitude was defined as job strain. Job support was determined by five items,[30] each carrying a value from zero to four, and thereby yielding a total score ranging from zero to 20. A score of 13 or less was considered ''exposed to low job support''.

Age was used as a continuous variable in all the multivariate analyses. Marital status was classified into four groups: married (which included those who cohabited without being married), unmarried, divorced, and widow/widower. The classification of country of origin in this study consisted of a simple dichotomy between people born in Sweden and those born in other countries.

Occupational class was classified according to job title and work tasks, using the manual issued by Statistics Sweden.[31] Based on the two digit socioeconomic status codes, five groups were constructed. Occupational class group V includes unskilled manual workers; group IV, skilled manual workers; group III, non-manual employees on a low level; group II, non-manual employees on a medium level; and group I comprises non-manual employees on a high level—that is, employees in leading positions and professionals with university degrees. Farmers (very few in this urban population) and entrepreneurs were excluded from the study when this variable was used in the analysis because of their unclear status in relation to other groups in this kind of socioeconomic scale (thus they are included in the category ''missing data'' in table 1).

Educational level was determined by the self reported total years of education, used in the analyses as a trichotomous

Table 3 Cumulative incidence and age adjusted odds ratios regarding shoulder pain in different sociodemographic groups among occupationally active men and women ages 45–64 in the Malmö shoulder and neck study

	Men				Women			
	Number	Number of cases	One year cumulative incidence (%)	Odds ratio (95% CI)	Number	Number of cases	One year cumulative incidence (%)	Odds ratio (95% CI)
Age								
45–49	506	28	5.5	1.0 (reference)	468	48	10.3	1.0 (reference)
50–54	947	57	6.0	1.09 (0.69, 1.74)	851	79	9.3	0.90 (0.61, 1.31)
55–59	781	53	6.8	1.24 (0.78, 1.99)	643	57	8.9	0.85 (0.57, 1.28)
60–64	415	19	4.6	0.82 (0.45, 1.49)	308	18	5.8	0.54 (0.31, 0.95)
Totals	2649	157	5.9		2270	202	8.9	
Country of origin								
Sweden	2410	139	5.8	1.0 (reference)	2094	186	8.9	1.0 (reference)
Other	238	18	7.6	1.33 (0.80, 2.22)*	176	16	9.1	1.03 (0.60, 1.76)
Marital status								
Married	1944	121	6.2	1.0 (reference)	1372	125	9.1	1.0 (reference)
Unmarried	290	11	3.8	0.58 (0.30, 1.09)*	240	11	4.6	0.46 (0.25, 0.87)
Divorced	363	21	5.8	0.91 (0.56, 1.50)*	536	60	11.2	1.25 (0.91, 1.74)
Widowed	52	4	7.7	1.28 (0.45, 3.62)*	121	6	5.0	0.57 (0.24, 1.32)
Educational level								
>12 years	705	31	4.4	1.0 (reference)	689	53	7.7	1.0 (reference)
10–12 years	953	49	5.1	1.18 (0.74, 1.87)*	918	70	7.6	1.02 (0.70, 1.48)
<9 years	990	77	7.8	1.86 (1.21, 2.86)*	662	79	11.9	1.75 (1.21, 2.54)
Occupational class								
High level non-manual	671	32	4.8	1.0 (reference)	357	29	8.1	1.0 (reference)
Middle level non-manual	593	23	3.9	0.80 (0.46, 1.39)*	496	29	5.8	0.72 (0.42, 1.23)
Low level non-manual	408	21	5.1	1.09 (0.62, 1.92)*	766	67	8.7	1.12 (0.71, 1.77)
Skilled manual	397	42	10.6	2.36 (1.46, 3.81)*	125	9	7.2	0.92 (0.42, 2.00)
Unskilled manual	330	28	8.5	1.84 (1.09, 3.11)*	472	64	13.6	1.86 (1.17, 2.96)
Pain from other regions								
No	2280	101	4.4	1.0 (reference)	1848	128	6.9	1.0 (reference)
Yes	369	56	15.2	3.88 (2.74, 5.49)*	419	74	17.7	2.92 (2.14, 3.97)

*Adjusted for age.

variable with the values ''nine or less educational years'', ''10 to 12 years'', and ''more than 12 years''.

As it has been claimed that musculoskeletal complaints could be a part of a generalised pain syndrome,[32] we constructed a variable termed ''pain from other regions''. People who reported pain from the lower back or from arms/hands at the baseline assessment were, by the definition stated above, classified as having ''pain from other regions''. This variable was used in the multivariate analysis to account for possible confounding from a generalised pain syndrome, which could be expected to have different causes than specific shoulder and neck pain.

Statistical methods

The associations between mechanical and psychosocial exposures and a one year cumulative incidence of shoulder and neck pain was calculated as an odds ratio (OR) and a 95% confidence interval (CI) was applied. Adjustments for potential confounders were made by logistic regression analysis. Educational level was chosen as the marker of socioeconomic status in the multivariate models, as it permitted the use of more people, and because occupational class was highly correlated to mechanical exposure, thus creating the risk of colinearity problems in the model. In this study, effect modification was defined as a departure from additivity, because, according to Rothman, this phenomenon should be evaluated on an additive scale.[33 34]

RESULTS

Table 1 describes the demographic and socioeconomic characteristics of the cohort. In tables 2 and 3, neck and shoulder pain were analysed separately to assess their similarity in relation to demographic and socioeconomic variables. It can be noted in table 2 that the cumulative incidence of neck pain seems to peak after the age of 50 in vocationally active men, while in vocationally active women it seems to reach its highest prevalence before age 50. The risk of developing neck pain during the follow up period was significantly higher among women born outside of Sweden (age adjusted OR = 1.81, 95% CI: 1.15, 2.92). It was also noted that occupational class was not a predictor for neck pain in women, while having a skilled manual occupation was significantly associated with a higher cumulative incidence among men (OR = 2.04, 95% CI: 1.27, 3.29, using high level non-manual employees as the reference). Moreover, being a widower was associated with a significantly increased risk.

Concerning educational level, there was a statistically significant higher risk for neck pain in the group of men with the least education. The age adjusted OR was 2.31 (95% CI: 1.48, 3.61). Pain from other musculoskeletal regions was a strong predictor in both sexes, supporting the notion of a generalised pain syndrome, with age adjusted ORs of 3.71 (95% CI: 2.62, 5.25) for men and 2.73 (95% CI: 1.47, 3.77) for women.

Basically the same pattern (except regarding country of origin) was found for shoulder pain (table 3), which justified the merging of the two pain categories in the further analyses.

In tables 4 (A) and (B) it can be noted that mechanical exposure was the strongest predictor for shoulder and neck pain. Statistically significant higher age adjusted ORs were found for both men and women (OR = 2.17, 95% CI: 1.65, 2.85 and OR = 1.59, 95% CI: 1.22, 2.06, respectively). Adjusting the ORs concerning mechanical exposure for job strain, too, produced a very marginal change.

High psychological job demands, low job decision latitude, and low job support were not associated with increased risk for getting neck and shoulder pain during follow up, either in men or in women. However, the combination of high

Table 4 (A) Risk for shoulder-neck pain in relation to mechanical and psychosocial exposure among occupationally active men between 45 and 64 years old in the Malmö shoulder and neck study

	Number	Number of cases	One year cumulative incidence	Odds ratio model 1*	Model 2†	Model 3‡	Model 4¶	Model 5§
Mechanical exposure								
Low	1730	114	6.6	1.0 (Reference)				
High	882	117	13.3	2.17 (1.65, 2.85)	2.16 (1.64, 2.85)	2.16 (1.63, 2.85)	1.95 (1.41, 2.63)	1.73 (1.28, 2.36)
Psychological demands								
Low	1267	106	8.4	1.0 (Reference)				
High	1369	130	9.5	1.03 (0.86, 1.48)	1.11 (0.84, 1.46)	1.08 (0.82, 1.42)	1.10 (0.84, 1.46)	1.04 (0.78, 1.38)
Decision latitude								
High	1848	158	8.5	1.0 (Reference)				
Low	792	78	9.8	1.13 (0.85, 1.52)	0.98 (0.73, 1.33)	0.99 (0.73, 1.33)	0.93 (0.69, 1.27)	0.93 (0.69, 1.27)
Job support								
High	1253	99	7.9	1.0 (Reference)				
Low	1369	135	9.9	1.22 (0.92, 1.60)	1.21 (0.91, 1.59)	1.20 (0.91, 1.59)	1.22 (0.92, 1.61)	1.14 (0.86, 1.51)
Job strain								
No	2293	198	8.6	1.0 (Reference)				
Yes	347	38	11.0	1.22 (0.84, 1.79)	1.02 (0.69, 1.50)	1.00 (0.68, 1.48)	0.97 (0.66, 1.44)	0.94 (0.63, 1.40)

Odds ratios are computed from one year cumulative incidence and adjusted stepwise for potential confounders. *Adjusted for age. †Adjusted for age and job strain (mechanical exposure) or mechanical exposure (psychological demands, decision latitude, job support, and job strain). ‡Adjusted for age and job strain (mechanical exposure) or mechanical exposure (psychological demands, decision latitude, job support, and job strain), marital status, and country of origin. ¶Adjusted for age and job strain (mechanical exposure) or mechanical exposure (psychological demands, decision latitude, job support, and job strain), marital status, country of origin, and educational level. §Adjusted for age and job strain (mechanical exposure) or mechanical exposure (psychological demands, decision latitude, job support, and job strain), marital status, country of origin, educational level, and pain from other regions.

psychosocial demands and low decision latitude (that is, job strain) showed a statistically significant risk in women, although not in men (age adjusted OR = 1.73, 95% CI: 1.29, 2.31 and OR = 1.22, 95% CI: 0.84, 1.79, respectively). Adjusting further for mechanical exposure reduced these risk estimates only slightly: the ORs remained statistically significant regarding job strain among women. Further adjustments for the factors previously mentioned, as well as for marital status, country of origin, and educational level, only marginally reduced the ORs regarding mechanical exposure and the work related psychosocial factors cited; all statistically significant associations remained. In the final model, the ORs were adjusted for pain in other regions as well, slightly decreasing them, and the risk estimate regarding high mechanical exposure among women lost its statistical significance.

The results of the analysis regarding effect modification between mechanical exposure and job strain are shown in table 5 (A) and (B). In the absence of mechanical exposure, job strain did not seem to infer a statistically significant risk of neck and shoulder pain in men or in women (age adjusted OR = 0.96, 95% CI: 0.49, 1.88 and OR = 1.33, 95% CI: 0.87, 2.05, respectively). In contrast, the effect of mechanical exposure in the absence of job strain showed a statistically significant impact in men, although not in women (age adjusted OR = 2.14, 95% CI: 1.59, 2.88 and OR = 1.33, 95% CI: 0.97, 1.83, respectively). Simultaneous exposure to both risk factors clearly increased the risk for shoulder and neck complaints in both men and women (age adjusted OR = 2.25, 95% CI: 1.41, 3.59 and OR = 2.60, 95% CI: 1.78, 3.79, respectively).

Adjusting these estimates for age, marital status, country of origin, and educational level slightly reduced the ORs, but did not change any case of statistical significance. Adjusting also for pain from other regions further decreased the ORs. Among men, the estimate regarding simultaneous

Table 4 (B) Risk for shoulder-neck pain in relation to mechanical and psychosocial exposure among occupationally active women between 45 and 64 years old in the Malmö shoulder and neck study

	Number	Number of cases	One year cumulative incidence	Odds ratio model 1*	Model 2†	Model 3‡	Model 4¶	Model 5§
Mechanical exposure								
Low	1488	155	10.4	1.0 (Reference)				
High	745	111	14.9	1.59 (1.22, 2.06)	1.49 (1.14, 1.94)	1.48 (1.13, 1.93)	1.39 (1.05, 1.82)	1.26 (0.95, 1.67)
Psychological demands								
Low	1197	131	10.9	1.0 (Reference)				
High	1053	136	12.9	1.17 (0.91, 1.52)	1.11 (0.85, 1.44)	1.12 (0.86, 1.46)	1.13 (0.87, 1.48)	1.10 (0.84, 1.44)
Decision latitude								
High	1191	128	10.7	1.0 (Reference)				
Low	1065	139	13.1	1.27 (0.98, 1.64)	1.22 (0.94, 1.58)	1.20 (0.92, 1.56)	1.18 (0.89, 1.55)	1.14 (0.87, 1.51)
Job support								
High	1185	130	11.0	1.0 (Reference)				
Low	1059	137	12.9	1.18 (0.91, 1.52)	1.15 (0.89, 1.49)	1.17 (0.90, 1.52)	1.18 (0.91, 1.53)	1.13 (0.87, 1.47)
Job strain								
No	1800	188	10.4	1.0 (Reference)				
Yes	452	77	17.0	1.73 (1.29, 2.31)	1.61 (1.20, 2.17)	1.60 (1.19, 2.15)	1.56 (1.16, 2.11)	1.49 (1.10, 2.03)

Odds ratios are computed from one year cumulative incidence and adjusted stepwise for potential confounders *Adjusted for age. †Adjusted for age and job strain (mechanical exposure) or mechanical exposure (psychological demands, decision latitude, job support, and job strain). ‡Adjusted for age and job strain (mechanical exposure) or mechanical exposure (psychological demands, decision latitude, job support, and job strain), marital status, and country of origin. ¶Adjusted for age and job strain (mechanical exposure) or mechanical exposure (psychological demands, decision latitude, job support, and job strain), marital status, country of origin, and educational level. §Adjusted for age and job strain (mechanical exposure) or mechanical exposure (psychological demands, decision latitude, job support, and job strain), marital status, country of origin, educational level, and pain from other regions.

Table 5 (A) Risk for shoulder-neck pain in relation to mechanical and psychosocial exposure among occupationally active men between 45 and 64 years old in the Malmö shoulder and neck study

	Number	Number of cases	One year cumulative incidence	Odds ratio (95%CI) model 1*	Odds ratio (95%CI) model 2†	Odds ratio (95%CI) model 3‡	Odds ratio (95%CI) model 4¶
No mechanical exposure/ no job strain	1567	103	6.6	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
No mechanical exposure/job strain	159	11	6.9	0.96 (0.49, 1.88)	0.96 (0.49, 1.89)	0.93 (0.47, 1.83)	0.91 (0.46, 1.80)
Mechanical exposure/ no job strain	697	91	13.1	2.14 (1.59, 2.88)	2.14 (1.59, 2.89)	1.93 (1.40, 2.66)	1.72 (1.25, 2.39)
Mechanical exposure/job strain	182	25	13.7	2.25 (1.41, 3.59)	2.19 (1.36, 3.52)	1.92 (1.17, 3.15)	1.64 (0.99, 2.73)

Odds ratios are computed from one year cumulative incidence for the different combinations of mechanical exposure and job strain to test for effect modification, and adjusted stepwise for potential confounders. *Adjusted for age. †Adjusted for age, marital status, and country of origin. ‡Adjusted for age, marital status, country of origin, and educational level. ¶Adjusted for age, marital status, country of origin, educational level, and pain from other regions.

mechanical exposure and job strain was just beneath the threshold for statistical significance, but not among women (OR = 1.64, 95% CI: 0.99, 2.73 and OR = 2 .01, 95% CI: 1.34, 3.01, respectively).

When synergy index was calculated by Rothman's method using the fully adjusted ORs, evidence for a synergistic mechanism was found for women, but not for men (synergy indices estimated at 2.20 and 1.02, respectively).

DISCUSSION

We found that mechanical exposure (for men) and job strain (for women)—in other words, the combination of high job demands and low job decision latitude—were the factors most strongly associated with a higher risk for developing shoulder and neck pain during the one year follow up period.

We also found evidence for a synergistic effect of these two factors in heightening the risk of developing shoulder and neck pain among women, but not among men.

Our results may have been biased by selection, misclassification, and confounding. It is probable that the most vulnerable people had left their jobs and thus were excluded from the cohort in this study—either because they were no longer pursuing a physically demanding vocation, or because they were already ill at the time of the baseline assessment. This would bias the risk estimates towards the null.

Furthermore, it is known that people who are ill have less of a tendency to participate in studies. A higher non-participation rate among people complaining of shoulder and neck pain during the follow up study could also lead to an underestimation of the true association between mechanical and psychosocial exposures and the incidence of shoulder and neck pain. In actuality, the high participation rate in our follow up study (86.6%) would render this possibility a negligible consideration.

Bias attributable to dependent misclassification should not influence the results of this prospective study, as the exposures were determined at baseline, and case status at follow up. However, another possibility of misclassification could be present, namely, between mechanical and psychosocial exposures. It is possible that exposure to one of these factors might affect the person's assessment of the other. However, the correlation coefficient between these two exposures were rather moderate ($r = 0.15$, not shown in tables), which ought to exclude the possibility that the results were very much influenced by this type of bias.

Another bias of importance could be confounding. One potential confounder could be age, but adjustment for this factor in the multivariate analysis only resulted in a very marginal change in the ORs.

The most important confounder to account for was job strain regarding the estimated impact of mechanical exposure, and mechanical exposure regarding the impact of job strain. However, including these variables in the model only decreased the age adjusted ORs slightly, without changing their statistical significance. It can, thus, be concluded that the impact of mechanical exposure and job strain on shoulder and neck pain exhibits little or no confounding by each others' effect.

Further potential confounding factors were marital status and country of origin. Once again, inclusion of these variables in the multivariate models hardly changed the ORs. Occupational status was not included in the multivariate analysis because of its close association with both mechanical and the psychosocial exposures. For this reason, the inclusion of occupational status in the multivariate model would most probably result in an over-adjusted model, or problems of multicolinearity. Educational level was therefore chosen as the variable denoting socioeconomic status in the

Table 5 (B) Risk for shoulder-neck pain in relation to mechanical and psychosocial exposure among occupationally active women between 45 and 64 years old in the Malmö shoulder and neck study

	Number	Number of cases	One year cumulative incidence	Odds ratio (95%CI) model 1*	Odds ratio (95%CI) model 2†	Odds ratio (95%CI) model 3‡	Odds ratio (95%CI) model 4¶
No mechanical exposure/no job strain	1243	121	9.7	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
No mechanical exposure/job strain	235	30	12.8	1.33 (0.87, 2.05)	1.35 (0.88, 2.07)	1.33 (0.86, 2.05)	1.29 (0.83, 2.00)
Mechanical exposure/ no job strain	527	65	12.3	1.33 (0.97, 1.83)	1.34 (0.97, 1.85)	1.27 (0.91, 1.75)	1.17 (0.83, 1.62)
Mechanical exposure/job strain	212	46	21.7	2.60 (1.78, 3.79)	2.54 (1.73, 3.72)	2.32 (1.56, 3.44)	2.01 (1.34, 3.01)

Odds ratios are computed from one year cumulative incidence for the different combinations of mechanical exposure and job strain to test for effect modification, and adjusted stepwise for potential confounders. *Adjusted for age. †Adjusted for age, marital status, and country of origin. ‡Adjusted for age, marital status, country of origin, and educational level. ¶Adjusted for age, marital status, country of origin, educational level, and pain from other regions.

Policy implication

These results suggest that interventions aiming at reducing the occurrence of shoulder and neck pain should include both mechanical and psychosocial factors.

What this paper adds

The most important finding in this study was that mechanical exposure has an impact on shoulder and neck pain in men and women, and so have work related psychosocial factors in women even when taking into account confounding for each others' effect. Furthermore, evidence for the existence of a synergistic relation between these two types of exposures among women in a vocationally active, urban, middle aged, general population.

confounding analysis. But even when this variable was added to the multivariate model, its effect on the risk estimate was moderate.

The calculated synergy index value was 1.02 for men and 2.20 for women, showing a synergistic relation between mechanical exposure and job among women, but not among men.

A number of previously published studies concerning shoulder and neck pain have included both mechanical and psychosocial exposures. Most of these have been performed within occupationally homogenous groups, such as newspaper workers,[35 36] transit operators,[17] forestry workers,[37] carpenters,[38] car workers,[39] homecare workers,[40] aluminium smelters,[41] students,[42] medical secretaries,[43] and female nursing staff.[44] However, there are a few studies that have used groups drawn from the general population.[13 45–52]

Most of the aforementioned studies were cross sectional,[17 35–41 43 44 46–48 51] and one was a case-referent study.[13] In these investigations, the effect of mechanical exposure was controlled for psychosocial exposure, and vice versa. However, only two studies assessed possible effect modification between the two types of exposure.[36 40] Both of these were cross sectional, and were based on occupationally homogenous samples (newspaper workers and female homecare workers).

Most of the studies mentioned used a kind of demand/control instrument to assess work related psychosocial exposure,[17 35–38 40–42 44 45 47 51] while a great variety of measures were used for assessing mechanical workload. These ranged from time spent in a certain occupation (for example, Krause *et al*[17]) to observational assessments of workload and postures (for example, Kamwendo *et al*[43]). A wide array of instruments was also used in these studies to determine shoulder and neck pain. In some instances, a version of the standardised Nordic questionnaire was used.[13 37 47]

In conclusion, there seems to be a lack of previous prospective studies that have been (1) undertaken on large, general, population based samples (or at least samples representing a wide variety of occupations/work tasks), and that (2) use well recognised instruments for assessing mechanical and psychosocial exposure. Such standards are required to optimally address the question of whether one or both of these exposures can be convincingly linked to shoulder and neck pain. The preceding caveat may especially hold true if the objective is a valid analysis of effect modification.[53]

In a recently published review article concerning neck pain, in which 22 cross sectional, two prospective, and one case-referent study were evaluated, the authors concluded that awkward work postures could be linked to neck disorders with a reasonable degree of certainty.[49] This coincides with our findings that mechanical exposure (as assessed by an index primarily based on awkward work postures) is associated with an increased risk of developing shoulder and neck pain during the follow up period, independent of psychosocial exposure.

In the case of women, we also found a statistically significant association between work related psychosocial factors such as job strain and the heightened risk of developing shoulder and neck pain during the follow up period, independent of mechanical exposure. Similarly, in some cross sectional studies, high psychosocial job demands were found to be associated with shoulder and neck pain—once again, independent of mechanical exposure.[17 35 37 47] Several studies found low decision latitude associated with this outcome—again, independent of mechanical exposure.[36 38 40 41] Other studies, however, failed to find such an association.[37 47] One prospective study, however, did find high decision latitude associated with an increased risk of shoulder/neck pain.[42]

Two studies found the combination of high job demands and low decision latitude (that is, job strain) associated with shoulder neck pain, independent of mechanical exposure,[44 47] agreeing with our findings concerning women. One of these studies comprised only women,[44] while the other consisted of a general population sample.[47]

It seems like effect modification between mechanical exposure and such psychosocial factors as job strain have been rather neglected in previous studies. We could only find two cross sectional studies—both with rather small, occupationally homogenous samples—addressing this issue.[36 40] The aforementioned studies both found support for a possible synergistic effect between mechanical exposure and psychosocial factors. One of them concluded that high job demands, low decision latitude, and low job support all acted synergistically vis-à-vis mechanical exposure regarding the risk for shoulder and neck disorders.[36] The other study found that low decision latitude acted synergistically regarding exposure to awkward body positions vis-à-vis the cited outcome.[40] It is noteworthy that one of these studies was solely comprised of female subjects.[40] Once more, this is basically in line with the results of our analysis of effect modification, namely, that there is statistically significant support for the existence of a synergistic relation between mechanical exposure and job strain in women (but not in men) when it comes to the risk of developing shoulder and neck pain.

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REFERENCES

1 **Bongers PM**, de Winter CR, Kompier MAJ, *et al*. Psychosocial factors at work and musculoskeletal disease. *Scand J Work Environ Health* 1993;**19**:297–312.

2 **Hagberg M**, Silverstein B, Wells R, *et al*. In: Kuorinka I, Forcier L, eds. *Work related musculoskeletal disorders (WMSDs): a reference book for prevention*. London: Taylor and Francis, 1995.
3 **Pålsson B**, Horstmann V, Attewell RG, *et al*. Sick-leave disabilty pensions among female assembly workers. *Eur J Public Health* 1997;**7**:162–8.
4 **Mäkelä M**, Heliövaara M, Impivaara O, *et al*. Prevalence, determinants, and consequences of chronic neck pain in Finland. *Am J Epidemiol* 1991;**134**:1356–67.
5 **National Board of Occupational Safety and Health**. *Occupational diseases and occupational accidents 1997*. [Arbetssjukdomar och arbetsolyckor 1997]. Solna, Sweden: NOBOSH, 1999.
6 **National Board on Health and Welfare**. *Public Health Report 1994*. [Folkhälsorapport 1994]. Stockholm: Socialstyrelsen, 1994.
7 **Tola S**, Riihimäki H, Videman T, *et al*. Neck and shoulder symptoms among men in machin operating, dynamic physical work and sedentary work. *Scand J Work Environ Health* 1988;**14**:299–305.
8 **Brage S**, Bjerkedal T. Musculoskeletal pain and smoking in Norway. *J Epidemiol Community Health* 1996;**50**:166–9.
9 **Buckle P**. Upper limb disorders and work: the importance of physical and psychosocial factors. *J Psychosom Res* 1997;**43**:17–25.
10 **National Institute for Occupational Safety and Health**. *Musculoskeletal disorders and workplace factors. A critical review of epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back*. Cincinnati, OH: NIOSH, 1997.
11 **Leclerc A**, Niedhammer I, Landr M-F, *et al*. One-year predictive factors for various aspects of neck disorders. *Spine* 1999;**24**:1455–62.
12 **Milerad E**, Ekenvall L. Symptoms of the neck and upper extremities in dentists. *Scand J Work Environ Health* 1990;**16**:129–34.
13 **Ekberg K**, Björkqvist B, Malm P, *et al*. Case-control study of risk factors for disease in the neck and shoulder area. *Occup Environ Med* 1994;**51**:262–6.
14 **Ekberg K**, Karlsson M, Axelson O, *et al*. Cross-sectional study of risk factors for symptoms in the neck and shoulder area. *Ergonomics* 1995;**38**:971–80.
15 **Vasseljen O**, Westgaard RH. Can stress-related shoulder and neck pain develop independently of muscle activity? *Pain* 1996;**64**:222–30.
16 **Viikari-Juntura ERA**. The scientific basis for making guidelines and standards to prevent work-related musculoskeletal disorders. *Ergonomics* 1997;**40**:1097–117.
17 **Krause N**, Ragland DR, Greiner BA, *et al*. Psychosocial job factors associated with back and neck pain in public transit operators. *Scand J Work Environ Health* 1997;**23**:179–86.
18 **Winkel J**, Mathiassen SE. Assessment of physical work exposures in epidemiological studies—concepts, issues and operational considerations. *Ergonomics* 1994;**37**:979–88.
19 **Hagberg M**. Occupational musculoskeletal stress and disorders of the neck and shoulder: a review of possible patophysiology. *Int Arch Occup Environ Health* 1984;**53**:269–78.
20 **Frank JW**, Pulcins IR, Kerr MS, *et al*. Occupational back pain—unhelpful polemic. *Scand J Work Environ Health* 1995;**21**:3–14.
21 **McAtamney L**, Corlett EN. RULA: a survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics* 1993;**24**:91–9.
22 **Moore JS**, Garg A. The strain index: a proposed method to analyze jobs for risk of distal upper extremity disorders. *Am Ind Hyg Assoc J* 1995;**134**:1356–67.
23 **Occhipinti E**. OCRA: a concise index for the assessment of exposure to repetitive movements of the upper limbs. *Ergonomics* 1998;**41**:1290–311.
24 **Balogh I**, Örbaek P, Winkel J, *et al*, and the Malmö Shoulder Neck Study Group. Questionnaire-based mechanical exposures indices for large population studies—Reliability, internal consistency and predictive validity. *Scand J Work Environ Health* 2001;**27**:41–8.
25 **Berglund G**, Elmståhl S, Janzon L, *et al*. Malmö diet and cancer study. Design and feasibility. *J Intern Med* 1993;**233**:45–51.
26 **Lindström M**, Hanson BS, Brunner E, *et al*. Socioeconomic differences in fat intake in a middle-aged population: report from the Malmö diet and cancer study. *Int J Epidemiol* 2000;**29**:438–48.
27 **Kuorinka I**, Jonsson B, Kilbom A, *et al*. Standardised Nordic questionnaire for the analysis of musculoskeletal symptoms. *Applied Ergonomics* 1987;**18**:233–7.
28 **Wiktorin C**, Wigaeus HE, Winkel J, *et al*. and the Stockholm MUSIC I Study Group. Reproducibility of a questionnaire for the assessment of physical exposures during work and leisure time. *J Occup Environ Med* 1996;**38**:190–201.
29 **Karasek R**, Theorell T. *Healthy work. Stress productivity and the reconstruction of working life*. New York: Basic Books, 1990.
30 **Johnson JV**. *The impact of place of work social support, job demands and work control upon cardiovascular disease in Sweden*. (Doctoral thesis). Stockholm: Department of Psychology, University of Stockholm, 1986.
31 **Statistics Sweden**. *Swedish socioeconomic classification*. (In Swedish). Stockholm: Statistics Sweden, 1982.
32 **Ektor-Andersen J**, Isacsson S-O, Lindgren A, *et al*. The experience of pain from the shoulder-neck area related to the total body pain, self-experienced health and mental distress. The Malmö Shoulder Neck Study Group. *Pain* 1999;**82**:289–95.
33 **Rothman KJ**. *Modern epidemiology*. Boston: Little, Brown, 1986.
34 **Greenland S**, Rothman KJ. Concept of Interaction. In: Rothman KJ, Greenland S, eds. *Modern epidemiology*. Philadelphia: Lippincott-Raven, 1998.
35 **Polonyi MF**, Cole DC, Beaton DE, *et al*. Upper limb work-related musculoskeletal disorders among newspaper employees: cross-sectional survey results. *Am J Ind Med* 1997;**32**:620–8.
36 **Faucett J**, Rempel D. VDT-related musculoskeletal symptoms: interactions between work posture and psychosocial work factors. *Am J Ind Med* 1994;**26**:597–612.
37 **Hagen KB**, Magnus P, Vetlesen K. Neck/shoulder and low-back disorders in the forestry industry. Relationship to work tasks and perceived psychosocial job stress. *Ergonomics* 1998;**41**:1510–18.
38 **Lemasters GK**, Atterbury MR, Booth-Jones AD, *et al*. Prevalence of work related musculoskeletal disorders in active union carpenters. *Occup Environ Med* 1998;**55**:421–7.
39 **Engström T**, Hanse JJ, Kadefors R. Musculoskeletal symptoms due to technical preconditions in long cycle time work in an automobile assembly plant.a study of prevalence on relation to psychosocial factors and physical exposure. *Applied Ergonomics* 1999;**30**:443–53.
40 **Brulin C**, Gerdle B, Granlund B, *et al*. Physical and psychosocial work-related risk factors associated with musculoskeletal symptoms among home care personnel. *Scand Caring Sci* 1998;**12**:104–10.
41 **Hughes RF**, Silverstein BA, Evanoff BA. Risk factors for work-related musculoskeletal disorders in an aluminium smelter. *Am J Ind Med* 1997;**32**:66–75.
42 **Barnekow-Bergkvist M**, Hedberg GE, Janlert U, *et al*. Determinants of self-reported neck-shoulder and low-back symptoms in a general population. *Spine* 1998;**23**:235–43.
43 **Kamwendo K**, Linton SJ, Moritz U. Neck and shoulder disorders in medical secretaries. Part I. Pain prevalence and risk factors. *Scand J Rehabil Med* 1991;**23**:127–33.
44 **Josephson M**, Lagerström M, Hagberg M, *et al*. Musculoskeletal symptoms and job strain among nursing personnel: a study over a three year period. *Occup Environ Med* 1997;**54**:681–5.
45 **Eriksen W**, Natvig B, Knardahl S, *et al*. Job characteristics as predictors of neck pain. A four year prospective study. *J Occup Environ Med* 1999;**41**:893–902.
46 **Pope DP**, Croft PR, Pritchard CM, *et al*. Occupational factors related to shoulder pain and disability. *Occup Environ Med* 1997;**54**:316–21.
47 **Toomingas A**, Theorell T, Michélsen H, *et al*. and the Stockholm MUSIC I Study Group. Associations between self-rated psychosocial work conditions and musculoskeletal symptoms and signs. *Scand J Work Environ Health* 1997;**23**:130–9.
48 **Linton SJ**. Risk factors for neck and back pain in a working population in Sweden. *Work and Stress* 1990;**4**:41–9.
49 **Fredriksson K**, Alfredsson L, Thorbjornsson CB, *et al*. Risk factors for neck and shoulder disorders: a nested case-control study covering a 24-year period. *Am J Ind Med* 2000;**38**:516–28.
50 **Feveile H**, Jensen C, Burr H. Risk factors for neck-shoulder and wrist-hand symptoms in a 5-year follow-up study of 3,990 employees in Denmark. *Int Arch Occup Environ Health* 2002;**75**:243–51.
51 **Andersen JH**, Kaeregaard A, Frost P, *et al*. Physical, psychosocial, and individual risk factors for neck/shoulder pain with pressure tenderness in the muscles among workers performing monotonous, repetitive work. *Spine* 2002;**27**:660–7.
52 **Harkness EF**, Macfarlane GJ, Nahit ES, *et al*. Mechanical and psychosocial factors predict new onset shoulder pain: a prospective cohort study of newly employed workers. *Occup Environ Med* 2003;**60**:850–7.
53 **Ariens GA**, van Mechelen W, Bongers PM, *et al*. Physical risk factors for neck pain. *Scand J Work Environ Health* 2000;**26**:7–19.