Risk factors in the onset of neck/shoulder pain in a prospective study of workers in industrial and service companies

J H Andersen, A Kaergaard, S Mikkelsen, U F Jensen, P Frost, J P Bonde, N Fallentin, J F Thomsen

Aims: To quantify the relative contribution of work related physical factors, psychosocial workplace factors, and individual factors and aspects of somatisation to the onset of neck/shoulder pain.

Methods: Four year prospective cohort study of workers from industrial and service companies in Denmark. Participants were 3123 workers, previously enrolled in a cross sectional study, where objective measurement of physical workplace factors was used. Eligible participants were followed on three subsequent occasions with approximately one year intervals. Outcomes of interest were: new onset of neck/shoulder pain (symptom cases); and neck/shoulder pain with pressure tenderness in the muscles of the neck/shoulder region (clinical cases).

Results: During follow up, 636 (14.1%) participants reported neck/shoulder pain of new onset; among these, 82 (1.7%) also had clinical signs of substantial muscle tenderness. High shoulder repetition was related to being a future symptom case, and a future clinical case. Repetition was strongly intercorrelated with other physical measures. High job demands were associated with future status as a symptom case, and as a clinical case. A high level of distress predicted subsequent neck/shoulder pain, and neck/shoulder pain with pressure tenderness.

Conclusions: High levels of distress, and physical and psychosocial workplace factors are predictors of onset of pain in the neck and/or shoulders, particularly pain with pressure tenderness in the muscles.

Main messages

• High physical workload was associated with onset of pain in the neck and/or shoulders, particularly pain with pressure tenderness.
• High job demands and low job control were independently associated with the onset of symptoms.
• Level of distress predicts future symptoms and clinical signs from the neck and/or shoulders.
• Women and men had an equal risk for new pain in the neck and/or shoulders, but women had a higher risk for future clinical case status.
• A general low pain pressure threshold did not predict future pressure tenderness in the neck and/or shoulders.

Policy implications

• A concerted action against physical workplace factors could probably prevent more serious neck and/or shoulder pain.
• Outsourcing of high strain jobs from the western countries calls for cooperation in research on musculoskeletal disorders.
• Further research in the origin of musculoskeletal problems would benefit from the inclusion of sociological and cultural factors.

Neck/shoulder pain is frequently reported among workers with repetitive manual tasks as well as among some service workers.1 2 The aetiology is largely unknown, and most studies so far are cross sectional.3 Prospective studies have been conducted, and physical and psychosocial workplace factors such as neck flexion, sitting, quantitative job demands, and coworker support have been found to be risk factors for neck pain in a recent study.4 5 Physi cal work with a heavy load, awkward postures, and mental stress were related to one-year incidence of shoulder pain.6 The multifactorial and multidimensional nature of musculoskeletal pain has been the subject of several studies, which have found that psychological distress and other somatic symptoms are related to unspecific pain complaints from the neck and upper extremity.7 8

We aimed to determine the contribution of: (a) physical workplace factors, (b) psychosocial workplace factors, and (c) individual factors and symptom reporting to the onset of new neck/shoulder pain and neck/shoulder pain with pressure tenderness.

METHODS

The study was conducted as a four year prospective cohort study, with yearly assessment of exposures in the workplace and simultaneous questionnaire screening and clinical examinations; fig 1 illustrates the total flow in the study.

Recruitment

The study population comprised 3123 workers from industrial and service sector settings, enrolled in 1994 and 1995. Three quarters of the population had mainly repetitive job tasks; a quarter had more varied jobs and served as a reference group. All workers included were unskilled blue collar or white collar workers.

Abbreviations: CI, confidence interval; OR, odds ratio
workers; the reference group did not differ from the group with repetitive work on educational level or salary.

The workplaces included four food processing companies, three textile plants, seven other manufacturing, and five service companies. Detailed description of the recruitment and the industries has been reported elsewhere.³

Questionnaire

All participants received a mailed questionnaire at baseline, and underwent a clinical examination at the workplace, focusing on clinical signs from the neck and upper extremities, including pressure tenderness in the following muscles: upper neck muscle, trapezius, supra- and infraspinatus.⁴ The pain pressure threshold in the lower extremities was recorded by a pressure algometer,⁵ and based on the 25th centile, the participants within the lowest pressure threshold were classified as having an overall low pain pressure threshold. Measures on height and weight were obtained and the BMI calculated as kg/m².

The questionnaire contained information on: (a) the psychosocial workplace factors job demands, job control, and social support from the job content questionnaire;⁶ (b) the personality trait of “intrinsic effort” from Siegrist’s effort-reward model, where the 29 items were summed to form an index and dichotomised into high versus low intrinsic effort; and (c) reporting of physical, emotional, and cognitive symptoms from the stress profile questionnaire developed by Setterlind.⁷ Eighteen questions were summed to create: zero for no distress (0 on the scale), one for minor distress (0.5 to 2 on the scale), and indisputable/severe palpation tenderness in the neck muscles or right upper trapezius border, and in the right supra- or infraspinatus muscle, they fulfilled the criteria for neck/shoulder pain with pressure tenderness (clinical case).⁸ Palpation tenderness was scored on a scale of 0 to 3 and dichotomised into indisputable/severe palpation tenderness (score 2 or 3), with withdrawal or jump sign at the palpation, and no or minor palpation tenderness (score 0 or 1).

Work related physical factors

The physical workplace factors were assessed at baseline by a task based strategy of exposure assessment using a real time video based method, which has been described earlier.⁹ There were four steps in the assessment. Firstly, ergonomists visited the 19 company sites and work tasks were classified as either repetitive or control tasks. A repetitive task was one that involved continuous repetitive hand or arm movements. A control task was characterised by varied job tasks. Examples of repetitive task groups are deboning ham, sewing machine work, deboning poultry, packing, continuous data entering, shop cashier, and manual machine feeding. Non-repetitive or control tasks included varied office work, supervision of machines, different kinds of maintenance work, or internal transportation.

Secondly, repetitive tasks with comparable levels of physical exposure—that is, same level of repetition, force, neck flexion, and lack of shoulder recovery time, were aggregated. On this basis five to six task groups were established on each working site, giving a total of 103 grouped tasks.

Thirdly, between one and seven workers in each of the 103 task groups were videotaped from three camera angles for at least 10 working cycles or for a minimum period of 10–15 minutes. The (a) number of shoulder movements/minute, (b) percentage of cycle time spent with neck flexion more than 20°, (c) percentage of cycle time spent with no upper arm support or rest for more than two seconds (lack of shoulder recovery time), and (d) force requirements¹⁰ subjectively assessed and
computed by the observer using five point ordinal scales (zero to four), relative to maximum voluntary contraction, were quantified based on repeated reviews of the video recordings. Each of the 103 repetitive task groups was assigned the median value for the measured neck and shoulder exposures.

The first step involved allocating time weighted exposure measures to participants on the basis of self reported task distribution during a normal week of 37 hours. Exposure measure was calculated by summing the products of task group exposure medians (level) and proportion of time (relative to a normal working week of 37 hours) spent per week in up to five task groups (time pondered)—that is, time weighted exposure = sum (up to five tasks) time pondered × level. The values for each exposure were divided into three levels on the basis of score distributions: the reference group was assigned the value of 0, and the repetitive group was assigned 1 (low) or 2 (high): repetitiveness (1–15 movements per minute/16–40 movements per minute, force (%10 of MVC/%10 of MVC), neck flexion >20° (<66% of time/%66 of time), and lack of recovery time (<80% of time/%80 of time).

Analysis
Two outcomes were of interest. Participants with pain scores sufficiently greater than the preceding round, as described above, were included as symptom cases. Participants not fulfilling clinical criteria at baseline were included as incident cases. The risk of developing pain and the defined clinical disorder was calculated with a logistic regression technique equivalent to discrete survival analysis.16 The number of follow up rounds taken to develop the outcome was analysed by logistic regression on the total number of observed follow up rounds. Observations were right censored when the criterion for the outcome became positive; table 1 shows participants at risk for either of the two outcomes. In the analyses of risk factors we applied models with time varying measures of observed and perceived workplace factors. In all analyses we used a time lagged function to link the outcomes with exposure characteristics on job demands, job control, social support, and level of other symptom reporting (distress) from the preceding round of follow up to diminish bias from simultaneous reporting of exposure and outcome. In the final, combined regression model the values (0 to 2) for the four physical exposure variables were summed up to an overall index ranging from 0 to 8, and further divided into low combined exposure (≤ 4), medium exposure (5–6 on index), and high exposure (7–8 on index). All determinants remained in the models whatever the magnitude or significance of effect.

RESULTS
The baseline cohort of 3123 workers was more than halved to 1546 (49.5%) in the study period, which lasted almost four years. The drop out was not related to exposure or musculoskeletal symptoms or disorders at baseline. The percentage with monotonous, repetitive work at baseline was 75%, and 68% at third follow up. We have earlier reported a baseline prevalence on 6.2% of neck/shoulder pain with pressure tenderness,3 and the prevalence among the 1546 participants at the end of follow up was 6.3%. Drop out was strongly related to young age, and to companies moving their production to Eastern Europe.

The average incidence of new neck/shoulder pain during follow up was 14.1%, and for neck/shoulder pain with pressure tenderness the average incidence was 1.7% (table 1).

Risk factors

Physical workplace factors
Repetitive movements of the shoulder were the strongest physical risk factor for future pain, and even more for being a future clinical case (adjusted OR 3.0, 95% CI 1.5 to 5.8; table 2). Workers having job tasks where the neck is flexed more than 20° for more than two thirds of their working time had an increased odds of being a clinical case (OR 2.6, 95% CI 1.3 to 5.1). We further examined whether greater time spent with the neck flexed more than 20° was more related to neck pain than to pain localised primarily to the shoulder. The crude odds ratio for onset of neck pain for participants working with the neck flexed for more than two thirds of their working time (OR 1.6, 95% CI 1.2 to 2.1), and for onset of shoulder pain (OR 1.8, 95% CI 1.4 to 2.3), were equal, and at the same level as for our neck/shoulder symptom case, which had an odds ratio of 1.6 (table 2). In general, risk estimates for being a future symptom case and a future clinical case had the same directions, but odds ratios for clinical case status were 65–100% higher than for being a symptom case. For those with highly repetitive work, the odds ratios for being a future clinical case increased when either a high percentage of time with neck flexion or a low recovery time was present. This trend persisted even without the reference group, indicating an internal exposure-response relation among workers with repetitive work (table 3).

Psychosocial workplace factors
High job demands and low job control were independently associated with the onset of symptoms and future clinical cases. Low social support was not significantly associated with either of the two outcomes (table 4). We found no significant contribution by including the interaction term for job demands and job control or social support.

Combined regression model
The four physical exposure values turned out to be highly correlated with correlation coefficients between 0.3 and 0.5, and data for combined physical exposure, job demands, gender, low pain pressure threshold, and level of distress were entered as covariates in a logistic regression model with either onset of symptoms and future clinical cases as outcomes. High physical exposure was a risk factor for symptom cases (OR 1.5, 95% CI 1.2 to 1.9) and for clinical cases (OR 3.2, 95% CI 1.6 to 6.6; table 5). High job demands stayed in both the models, whereas being a woman only revealed an increased risk for being a future clinical case. Low pain pressure threshold at baseline was a minor risk factor for symptom cases, but not for clinical cases. Level of distress in the follow up round preceding case status showed an exposure-response relation between level of distress and incidence of new symptoms and clinical case status (table 5).

DISCUSSION
Incidence of neck/shoulder pain and pain in combination with clinical signs of pressure tenderness, was independently related to work related physical factors, high job demands, and to precedent distress. Low pain pressure threshold predicted symptoms but not future clinical status, which was in contradiction to our findings in the baseline of this population.4 This finding indicates that the cross sectional association could be caused by central sensitisation and spreading of localised pain. Women were at higher risk of being a clinical case, but not a symptom case. Personality traits measured by Siegrist’s intrinsic effort were not related to future pain or clinical signs. The risk estimates for onset of neck/shoulder pain with pressure tenderness were higher for all physical risk factors in this follow up analysis than in the same analysis at the cross sectional level.

Despite 50% drop out in four years of this study, baseline characteristics on exposures and the outcomes under study were quite similar among the participants who dropped out and among those who were successfully followed up. Three textile companies outsourced their production, other
companies reorganised, and the only individual predictor for
drop out was young age, reflecting the fact that many jobs in
supermarkets, poultry processing plants, postal services, and
elsewhere are held youths for short time intervals, while they
are preparing forthcoming education or employment in less
physically demanding and better paid jobs. A Swedish study
also found that drop out was caused by reasons unrelated to
exposure and outcome.

To our knowledge, the only other follow up study which
benefits from a more objective measurement of physical load
(that is, video recordings at the workplace) is the smash study
from the Netherlands. They used regular or prolonged neck
pain in the previous 12 months as the outcome, and found
that 14.4% reported that they had neck pain at least once
during a total follow up period of three years. We found an
annual occurrence of 14.1% for future onset of neck/shoulder
pain with our definition. They found that sitting for more
than 95% of the working time was a risk factor for neck pain
and a trend was found for neck flexion for 60–70% of time
and more than 70% of time. We found comparable increased
risk related to neck flexion for more than two thirds of the
working time, and our larger study supplied more statistical
power. The relation between sitting time and neck pain is
explained by a possible relation between prolonged sitting
and continuous static load on the neck muscles, but this load
was not measured. We assessed a measure for lack of recovery
time in the shoulder for more than two seconds, and provide

<table>
<thead>
<tr>
<th>Physical risk factor</th>
<th>Symptom cases n</th>
<th>Cases</th>
<th>OR* crude</th>
<th>ORadj† (95% CI)</th>
<th>OR* crude</th>
<th>ORadj† (95% CI)</th>
</tr>
</thead>
</table>
| Repetitivity (shoulder movements/min) Reference 1536 179 1.0 1.0 1600 14 1.0 1.0
| Low (1–15 movements/min) 1803 239 1.1 1.1 (0.9 to 1.3) 1986 27 1.3 (0.9 to 2.6) 1204 40 3.9 3.0 (1.5 to 5.8)
| High (16–40 movements/min) 1132 204 1.7 1.5 (1.2 to 1.9) |

**Table 2** Physical risk factors for onset of neck/shoulder pain (symptom cases), and neck/shoulder pain with pressure tenderness (clinical cases) among industrial and service workers

<table>
<thead>
<tr>
<th>Physical risk factor</th>
<th>Symptom cases n</th>
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| High (16–40 movements/min) 1132 204 1.7 1.5 (1.2 to 1.9) |

**Table 3** Combined physical risk factors for onset of neck/shoulder pain with pressure tenderness (clinical cases) among industrial workers

<table>
<thead>
<tr>
<th>Combined physical exposure</th>
<th>n</th>
<th>Cases</th>
<th>OR* crude</th>
<th>ORadj† (95% CI)</th>
</tr>
</thead>
</table>
| Repetition and force Reference 1600 14 1.0 1.0
| Low repetition and low force 1421 22 1.8 1.3 (0.6 to 2.7) 1.0
| High repetition and low force 638 26 4.8 3.3 (1.6 to 6.9) 2.4 (1.3 to 4.5)
| Low repetition and high force 475 5 1.2 1.3 (0.4 to 3.7) 1.1 (0.4 to 3.1)
| High repetition and high force 566 14 2.9 2.6 (1.2 to 5.9) 2.2 (1.1 to 4.7)

*OR, odds ratio.
†Adjustment for individual factors: age, gender, body mass index, pain pressure threshold, intrinsic effort, physical leisure time activity, psychosocial risk factors, and level of distress.
‡Exclusion of non-exposed reference group. Same adjustments as in †.
measure for static load was associated with pain and clinical signs as well, especially in combination with high repetition (table 3). We would though prefer terms like “a more continuous load” or “lack of recovery time” implying that static load describes something suitable for laboratory circumstances, where a static load could be simulated for maybe several minutes, but not for hours in a working day. The smash study found increased risk for high quantitative job demands and low coworker support in relation to neck pain. We only could support a significant contribution of job demands and for future symptoms also for job control, but not for social support. Dividing social support into coworker and supervisor support in our population did not provide more insight.

Our findings that future pain and clinical signs were strongly related to previously having other symptoms indicative of distress or maybe aspects of somatisation adds to similar results for forearm pain, chronic widespread pain, back pain, and shoulder pain.

What is neck/shoulder pain?

This study emphasises the multifactorial nature of neck/shoulder pain. Others have advocated making a distinction between risk factors for neck pain and shoulder pain. We found no support for the risk factors studied here having a differential impact on neck pain and shoulder pain, and as long as the outcomes are diffuse pain, and the exposures are broad and unspecified, such as sitting time, we do not think it is of obvious importance to distinguish. In clinical practice pain complaints from the neck, the shoulder girdle, and part of the shoulder go together. In our data the physical loads were strongly inter-correlated, which diminished our ability to disentangle the effect of each of the physical exposures. Repetitive movements of the shoulder and arm stands out as the most important physical risk factor, but work tasks with high repetition were often characterised by low percentage of recovery time and high percentage of time with neck flexed; this combination of adverse physical factors was also related to rating the work as a job with high demands and low control.

Future studies should consider the importance of all the risk factors, and elucidate different risk factors for onset of pain, amplification of pain, development to disorders, and to disability, in more detail. In addition to addressing workplace interventions, much could in our opinion be gained by avoiding misleading terms, avoiding further somatisation, avoiding unnecessary sick leave, and avoiding everyday pain and aches to be further medicalised.

| Table 4 | Psychosocial risk factors for onset of neck/shoulder pain (symptom cases) and neck/shoulder pain with pressure tenderness (clinical cases) |
|------------------|------------------|------------------|------------------|------------------|
|                  | Symptom cases (n=636) |                  |                  |                  |
|                  |                  | Clinical cases (n=82) |                  |                  |
|                   | OR<sub>crude</sub> * (95% CI) | OR<sub>adj†</sub> (95% CI) | OR<sub>crude</sub> (95% CI) | OR<sub>adj†</sub> (95% CI) |
| **Risk factor**   | **n**            |                  |                  |                  |
| Job demands       |                  |                  |                  |                  |
| Low               | 2880             | 1.0              | 1.0              | 1.0              |
| High              | 1805             | 1.7 (1.5 to 2.0) | 1.5 (1.3 to 1.8) | 2.3 (1.4 to 3.5) | 1.7 (1.1 to 2.9) |
| Job control       |                  |                  |                  |                  |
| High              | 3329             | 1.0              | 1.0              | 1.0              |
| Low               | 1348             | 1.4 (1.2 to 1.7) | 1.2 (1.0 to 1.5) | 1.8 (1.1 to 2.8) | 1.3 (0.8 to 2.1) |
| Social support    |                  |                  |                  |                  |
| High              | 3214             | 1.0              | 1.0              | 1.0              |
| Low               | 1216             | 1.1 (0.9 to 1.3) | 1.0 (0.9 to 1.3) | 1.4 (0.8 to 2.2) | 1.3 (0.8 to 2.1) |
| *OR, odds ratio.  |                  |                  |                  |                  |
| †Adjusted for all psychosocial factors (other factors in the table), physical risk factors, and individual factors: age, gender, body mass index, intrinsic effort, physical leisure time activity, and level of distress.

| Table 5 | Combined regression model of risk factors for onset of neck/shoulder pain (symptom cases) and neck/shoulder pain with pressure tenderness (clinical cases) |
|------------------|------------------|------------------|------------------|------------------|
|                  | Symptom cases (n=636) |                  |                  |                  |
|                  | Clinical cases (n=82) |                  |                  |                  |
| **Exposure**     | Odds ratio (95% CI) | Odds ratio (95% CI) | Odds ratio (95% CI) | Odds ratio (95% CI) |
| Combined physical exposure* |                  |                  |                  |                  |
| Reference category | 1                |                  |                  |                  |
| Low               | 1.1 (0.6 to 1.9)   | 1.3 (0.3 to 6.0)  |                  |                  |
| Medium            | 1.1 (0.9 to 1.4)   | 1.8 (0.9 to 3.6)  |                  |                  |
| High              | 1.5 (1.2 to 1.9)   | 3.2 (1.6 to 6.6)  |                  |                  |
| Job demands       |                  |                  |                  |                  |
| Reference category | 1                |                  |                  |                  |
| High job demands  | 1.5 (1.3 to 1.8)   | 2.0 (1.2 to 3.3)  |                  |                  |
| Gender            |                  |                  |                  |                  |
| Male              | 1                |                  |                  |                  |
| Women             | 0.9 (0.8 to 1.1)   | 1.8 (1.1 to 3.2)  |                  |                  |
| Pain pressure threshold |                  |                  |                  |                  |
| Reference—the high threshold | 1          |                  |                  |                  |
| Low               | 1.3 (1.1 to 1.5)   | 0.8 (0.5 to 1.3)  |                  |                  |
| Level of distress  |                  |                  |                  |                  |
| Low               | 1                |                  |                  |                  |
| Medium            | 1.4 (1.1 to 1.7)   | 1.7 (1.0 to 2.9)  |                  |                  |
| High              | 1.8 (1.4 to 2.5)   | 2.8 (1.4 to 5.4)  |                  |                  |
| *Physical strain index on the basis of shoulder repetition, force requirements, percentage with neck flexion more than 20°, and percentage of time with lack of recovery. High physical exposure is high level on at least three of the four quantitative measures.
Respiratory physicians rule on fitness to dive

Formal guidelines on deciding respiratory fitness for subaquea diving are available to physicians and GPS for the first time from the British Thoracic Society. Diving as a sport is booming, and doctors will be asked to assess fitness to dive more often and more stringently. They now have ready access to practical evidence based advice and guidance on when to seek specialist opinion. Both evidence and recommendations are graded according to SIGN criteria, and the guidelines will be audited for their usefulness.

The diving environment and its physiological effects pose special risks to divers. Pressure effects, decompression illness, and pulmonary oedema are all direct hazards. Then there are the effects of pre-existing respiratory illness and the potential need to be able to rescue another diver in difficulty. All are brought to bear in assessing fitness to dive.

Essentially, anyone without existing respiratory symptoms or previous lung disease or injury is fit to dive if respiratory examination and spirometric and PEFR measurements show no abnormalities, otherwise they are not. Anyone with respiratory symptoms or previous lung disease or injury is fit to dive if these measurements, plus chest and x-ray examination, are normal, unless the condition is one that precludes diving or needs further specialist advice.

Such conditions are lung bullae or cysts, previous spontaneous pneumothorax, some types of asthma, COPD, active sarcoidosis or tuberculosis and other serious lung conditions. Whatever the respiratory picture, though, ruling out other conditions that might compromise diver safety—diabetes or epilepsy—is essential.

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