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The role of work stress and psychological factors in the development of musculoskeletal disorders

The stress and MSD study

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The role of work stress and psychological factors in the development of musculoskeletal disorders

The stress and MSD study

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This research was conducted to establish the role of stress and other psychological factors on the development and reporting of musculoskeletal disorders.

A prospective epidemiological cohort study design was chosen. This comprised a baseline cross-sectional study of 8,000 workers of whom 3,139 were followed for 15 months (approx.) The cohort was drawn from 20 organisations across 11 industrial sectors in the U.K.

Extrinsic effort, intrinsic effort, role conflict and verbal abuse or confrontations with clients or the general public were psychosocial workplace risk factors for high perceived job stress. Individual factors such as age, gender, neuroticism, rumination and lay beliefs about the causes and alleviation of stress were unlikely to be involved in the development of high perceived job stress.

High perceived job stress was an intermediate factor between high exposure to both physical and psychosocial work risk factors and self-reported low-back, upper back and hands/wrists complaints. Psychosomatic symptoms, depression and perceived life stress may act independently to increase the likelihood of developing musculoskeletal complaints.

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EXECUTIVE SUMMARY

Aim

This research was conducted to establish the role of stress and other psychological factors on the development and reporting of musculoskeletal disorders. There were two main objectives. Firstly, to investigate factors that increased the likelihood of reporting high perceived job stress and secondly to investigate whether high perceived job stress and other stress reactions increased the likelihood of reporting musculoskeletal complaints.

Method

A prospective epidemiological cohort study design was chosen. This comprised a baseline cross-sectional study of 8,000 workers of whom 3,139 were followed for 15 months (approx.) The cohort was drawn from 20 organisations across 11 industrial sectors in the U.K.

A questionnaire was used to collect the baseline and follow-up data. Physical and psychosocial work factors, demographics, organisation factors, individual trait, attitude and well-being factors, stress reactions (perceived job stress, perceived life stress, depression, mental strain, psychosomatic symptoms) and musculoskeletal complaints were measured at baseline (see Appendix 8). The follow-up questionnaire measured perceived job stress and musculoskeletal complaints.

Separate cross-sectional and prospective analyses were performed using multiple logistic regression modelling for high perceived job stress and musculoskeletal complaints of the lower back, upper back, neck, shoulders, elbows/forearms and hands/wrists. The analyses considered whether the factors associated with the outcomes at baseline also increased the likelihood of developing the outcomes in the follow-up. This established association and time order between variables, two essential criteria for causation.

Results

Response rate: The response rate for the baseline cross-sectional study was 39% (n=3139) with company rates varying between 10-80%. Of the respondents, about 70% were white-collar workers (e.g. office workers, computer operators, technicians etc) and 30% were blue collar workers (e.g. delivery drivers, manual handlers, production line workers, oil rig workers). An 86% response rate was obtained for the follow-up questionnaire (after excluding those who had left the participating organisations.)

Job stress and musculoskeletal disorders:

Results of individual factors for job stress: Individual factors such as age, gender, neuroticism, rumination and lay beliefs about the causes and alleviation of stress were associated with reporting high perceived job stress. However, none of these factors increased the likelihood of reporting this outcome among workers who developed high perceived job stress during the follow-up.

Results of workplace factors for job stress: In the base-line cross-sectional study, workers highly exposed to both physical (always or often working with the back in an awkward position) and psychosocial work risk factors (extrinsic effort, intrinsic effort, role ambiguity, role conflict and verbal abuse or confrontations with clients or the general public) had the greatest likelihood of reporting high perceived job stress.

A tentative interaction effect (indicated by a departure from an additive model) between physical and psychosocial workplace risk factors was observed in the base-line cross-sectional study. High exposure to both physical and psychosocial work risk factors did not increase the likelihood of reporting high perceived job stress during the follow-up.

The psychosocial work factors associated with reporting high perceived job stress in the cross-sectional study and which also increased the likelihood of reporting the outcome in the follow-up study were extrinsic effort, intrinsic effort, role conflict and verbal abuse or confrontations with clients or the general public.

Extrinsic effort concerns job demands such as constant time pressure, interruptions and disturbances at work, job responsibility, pressure to work overtime and increasing demands of the job. Intrinsic effort in this study refers to an individual coping pattern characterised by being overwhelmed by time pressures, inability to relax and switch off after work and sacrificing too much for the job. Role conflict concerns the need to do things differently, dealing with incompatible requests, conflict with personal values and having assignments without adequate resources. Verbal abuse or confrontations with clients or the general public also implies conflict but with external relations outside of the work organisation.

Other psychosocial work factors such as role ambiguity, social support, rewards, job future ambiguity, decision latitude and threat of physical harm or injury did not increase the likelihood of reporting high perceived job stress in both the cross-sectional study and the follow-up study.

Results of individual factors for musculoskeletal complaints: Lay beliefs about the causes and alleviation of stress did not increase the likelihood of reporting new episodes of self-reported musculoskeletal complaints.

In general, individual factors (such as neuroticism, rumination, job satisfaction, negative mood and demographics) were not implicated in the causation of self-reported musculoskeletal complaints. However, increasing age was a significant factor for both self-reported elbows/forearm complaints and for shoulder complaints, whilst being female was a significant factor for reporting shoulder complaints.

Results of workplace factors for musculoskeletal complaints: In the cross-sectional study, high exposure to both physical and psychosocial work risk factors was associated with the reporting of low-back, upper back, neck, shoulder, elbow/forearm and hand/wrist musculoskeletal complaints. The specific risk factors are shown in the summary box below. A tentative interaction effect between physical and psychosocial workplace risk factors was observed for the lower back, the neck, the shoulder, the elbow/forearm and the hand/wrists but not for the upper back.

In the follow-up study, high exposure to both physical and psychosocial work risk factors also increased the likelihood of reporting new episodes of self-reported low-back, neck, shoulder, elbow/forearm and hand/wrist complaints. High exposure to both physical and psychosocial work risk factors did not increase the likelihood of reporting new episodes of upper back complaints.

Results of individual stress reactions for musculoskeletal complaints: Psychosomatic symptoms increased the likelihood of reporting new episodes of self-reported upper back, shoulder and hand/wrist complaints. Depression increased the likelihood of new episodes of self-reported musculoskeletal complaints affecting the upper back, neck and elbows/forearms. Perceived life stress increased the likelihood of new episodes of self-reported shoulder complaints.

A summary of the physical and psychosocial work risk factors for each body region is presented in the box below:

Low Back Complaints	**Physical work risk factors** • lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position • pushing and pulling objects combined with tasks requiring lifting	**Psychosocial work risk factors** • extrinsic effort • intrinsic effort • role conflict • threat of physical harm or injury
Neck complaints	**Physical work risk factors** • lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position • working with the head/neck bent or twisted excessively • vibration from a power tool or machine that made the hands vibrate during the past week • sitting and using a computer more than half the time • seated for 30 minutes or more without a break whilst carrying out work	**Psychosocial work risk factors** • intrinsic effort • job future ambiguity • verbal abuse and/or confrontations with clients or the general public
Shoulder complaints	**Physical work risk factors** • working with the head/neck bent or twisted excessively • lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position • repetitive wrist movements for much of the normal working day • repetitive arm movements • seated for 30 minutes or more without a break	**Psychosocial work risk factors** • low social support • low reward • job future ambiguity • threat of harm/injury
Elbow/forearm complaints	**Physical work risk factors** • vibration from a power tool or machine that made the hands vibrate during the past week • repetitive arm movements • performing work with a deviated or bent wrist position	**Psychosocial work risk factors** • low decision latitude • social support • reward • role conflict • job future ambiguity • threat of harm/injury
Hand/wrist complaints	**Physical work risk factors** • vibration from a power tool or machine that made the hands vibrate during the past week • repetitive wrist movements for much of the normal working day • repetitive arm movements • using a keyboard more than four hours per day • performing work with a deviated or bent wrist position	**Psychosocial work risk factors** • intrinsic effort • role ambiguity • job future ambiguity

Whilst perceived job stress did not increase the likelihood of new episodes of self-reported musculoskeletal complaints, it was involved as an intermediate factor between high exposure to

physical and psychosocial work risk factors and the outcome for the low-back, the upper back and hands/wrists.

Conclusions

The strength of this prospective study lies in the size of the cohort, the range of industrial sectors and occupational groups included, and the stress reactions and musculoskeletal problems measured. Exposure assessment has utilised psychometrically tested scales and, because the exposures have preceded the outcomes, time order effects have been investigated. The results provide strong epidemiological evidence regarding causative links between variables.

Individual demographics, traits, attitudes or wellbeing factors were not implicated in the causation of self-reported musculoskeletal complaints.

Individual stress reactions, for example, depression and psychosomatic symptoms acted independently to increase the likelihood of developing self-reported musculoskeletal complaints.

Perceived job stress may act as an intermediate factor between high exposure to physical and psychosocial work risk factors and the reporting of some musculoskeletal complaints.

High exposure to both physical and psychosocial work risk factors resulted in the greatest likelihood of reporting musculoskeletal complaints.

Implications of the Study: Interventions designed to reduce the risk of self-reported musculoskeletal complaints need to consider the degree of exposure both to physical work risk factors and psychosocial work risk factors. They should also consider the individual stress reactions that workers may be experiencing. Further research on interventions for reducing both work-related stress and work-related musculoskeletal disorders is needed.

1 INTRODUCTION

Work-related stress and work-related musculoskeletal disorders (WMSDs) are the leading occupational health problems in the European Union. In the UK, these disorders are the two leading causes of work absence and turnover. Data from SWI 2001/2002 shows that in the last 12 months of the survey 5.7 million working days were lost from back injuries, 4.1 million working days were lost from work-related upper limb disorders, and 13.4 million working days were lost due to stress-related disorders (average figures). The Health and Safety Executive estimate that this costs employer's between £315-335 million for back disorders and £208-221 million for work-related upper limb disorders. On average, stress, depression or anxiety accounts for an average of 29 days lost per case whereas for musculoskeletal disorders in general 19 days are lost per case (Health and Safety Commission, 2003).

In order to tackle this ever-increasing burden to society, the Health and Safety Executive have set targets for reducing both work-related stress and work-related musculoskeletal disorders in the UK.

It is important to understand the factors that lead to the development of work stress and work-related musculoskeletal disorders, both for prevention and rehabilitation. Scientific reports compiled by researchers for the European Agency for Safety and Health at Work on work-related stress and work-related musculoskeletal disorders make reference to both physical and psychosocial workplace risk factors (Buckle & Devereux, 1999; Cox et al., 2000; Op De Beeck & Hermans, 2000).

Systematic critical literature reviews regarding physical workplace risk factors for WMSDs have been consistent in their findings. For musculoskeletal disorders affecting the neck region, high postural load has been shown consistently to be a risk factor (duration of sitting, twisting and bending of the trunk) (Ariëns et al., 2001a). For the upper limbs, there is strong evidence that the biomechanical load from a combination of repetition, force and posture increases the risk multiplicatively for musculoskeletal disorders affecting the elbow (NIOSH, 1997). The combination effects have also been shown to increase the risk of specific hand disorders, i.e. carpal tunnel syndrome and tendinitis.

In a systematic critical review of Display Screen Equipment (DSE) users, there were consistent study findings regarding increasing duration of DSE use and increasing risk of neck/shoulder and hand/wrist musculoskeletal disorders (Punnett & Bergqvist, 1997). The relationship was mainly dependent on the degree of repetitive finger motion and sustained muscle loading across the forearm and wrist. At least 4 hours of keyboard work per day appeared to increase risk about two-fold compared to little or no keyboard work.

Some Hand-Arm Vibration Syndromes HAVS (for example, vibration-induced white finger) have clearer cause-effect relationships compared to other WMSDs. It is widely accepted that vibration is the main causal agent, however, the relationship between vibration and HAVS may also be modified by various environmental and individual variables (Bovenzi, 1998).

For the lower back, there has been consistency among critical reviews that lifting and whole body vibration are involved in the causation of lower back problems (Hoogendoorn et al., 2000; National Research Council & Institute of Medicine, 2001). The relationship between manual handling activities (specifically pushing and pulling) and lower back problems is less clear (Hoozemans et al., 1998).

A number of critical literature reviews have found evidence that psychosocial workplace risk factors are related to WMSDs (Ariëns et al., 2001b; Bongers et al., 2002; Hoogendoorn et al., 2002; National Research Council & Institute of Medicine, 2001; NIOSH, 1997).

Psychosocial workplace risk factors refer to individual subjective perceptions by workers regarding aspects of the organisation of work and carry emotional value, for example perceived job demands and degree of support from managers or coworkers. Work organisation factors describe characteristics of the work system, for example hours worked, work-rest cycles, culture, management style etc and have the potential for causing physical or psychological damage to health. These are not globally accepted definitions but are considered suitable for the purposes of this report.

Work organisation and psychosocial workplace risk factors have been included in HSG60(rev), the revised guidance on upper limb disorders in the workplace by the HSE (Health and Safety Executive, 2002). Based on an extensive review of the literature, work organisation and psychosocial workplace risk factors have been grouped into the following categories (Rick et al., 2002):

- demands – poorly designed/managed workload, work scheduling, work organisation, job design and physical environment.
- control – lack of skill discretion and lack of authority.
- support – appropriate proactive and reactive support, failure to match people's skills with their job, failure to take account of other individual factors.
- relationships – poorly designed/managed procedures for eliminating damaging conflict at individual/team level (bullying, harassment).
- role – role conflict, inappropriate levels of role ambiguity, inappropriate levels of responsibility.
- change – lack of planned, active strategy for change, poorly designed/managed strategies for overcoming resistance, lack of appropriate consultation with employees over change, lack of appropriate support for employees, poorly designed/managed new ways of working or new technology.

Other work factors may be related to WMSDs such as rewards concerning money, esteem and career opportunities and intrinsic effort concerning the personal pattern of coping with demands and demonstrating overcommitment on the job. Intrinsic effort reflects excessive striving in combination with a strong desire of being approved and esteemed. However, these factors have not been investigated in musculoskeletal disorder research.

Plausible models, supported by recent laboratory experimentation, have provided support for an interactive relationship between physical and psychosocial risk factors in the workplace (Davis & Heaney, 2000; Lundberg, 2002). For example, high mental workload and job demands may increase muscle tension and decrease micropauses in muscle activity, resulting in muscle fatigue. This mechanism may apply in tasks that require low levels of muscular activity. Additionally, mental load and job demands may result in adverse changes in immune system response. High levels of perceived job demands may alter behavioural work patterns in such a way as to increase exposure to biomechanical loads. For example, not taking rest breaks or adopting bad work practices to get the work done quicker may result in changes in trunk kinematics, the forces exerted or muscle activity that increase the loading on the musculoskeletal system. This may increase awareness and the reporting of musculoskeletal complaints.

A number of epidemiological studies have shown a combined effect of physical and psychosocial work risk factors on WMSDs (Bildt Thorbjörnsson et al., 1998; Devereux et al., 1999; Devereux et al., 2002; Fredriksson et al., 2000; Kerr et al., 2001; Krause et al., 1998; MacDonald et al., 2001). In the UK, a study was conducted to investigate whether there was an excess risk due to the interaction between physical and psychosocial work risk factors (Devereux et al., 1999; Devereux et al., 2002). The study showed that high exposure to a combination of recognised psychosocial risk factors, high mental demands, low job control and poor social support had an independent risk effect on musculoskeletal complaints. In addition, a interactive effect (indicated by a departure from an additive model of risk) between physical and psychosocial work risk factors was also likely. Such an interactive effect has important implications for prevention (Kleinbaum et al., 1982).

Stress has been implicated in the pathway between physical and psychosocial workplace risk factors and WMSDs (Bongers et al., 2002; Carayon et al., 1999). In the stress process, an individual's cognition and subjective appraisal of a potential risk factor is considered crucially important (Rydstedt et al., 2003). Sustained stress responses may result in increased muscle coactivation and thus increased loading on the musculoskeletal system. In addition, perceived job stress may reduce the ability for the musculoskeletal system to recover during or after work. In addition, central nervous system responses to perceived job stress may increase sensitisation to pain stimuli.

Most of the epidemiological literature investigating the relationship between mental stress reactions (symptoms of stress, perceived stress and depression) and WMSDs has been cross-sectional in design making it difficult to determine whether mental stress reactions were involved in the development of musculoskeletal disorders. None the less, cross-sectional studies have shown a positive association between stress and WMSDs (Bongers et al., 2002; Davis & Heaney, 2000; National Research Council & Institute of Medicine, 2001).

There is some evidence from prospective epidemiological studies that support a relationship between symptoms of stress/psychological strain and lower back problems (Feyer et al., 2000; Leino & Magni, 1993; Power et al., 2001; Tubach et al., 2002). However, other prospective studies have not shown this relationship (Harkness et al., 2003; Manninen et al., 1995). The relationship between depression and low-back problems also remains unclear.

For neck/shoulder problems, some prospective epidemiological studies have shown a positive relationship between symptoms of stress/psychological strain (Leclerc et al., 1999; Leino & Magni, 1993; Pietri-Taleb et al., 1994). Depression and anxiety has also been shown to predict musculoskeletal problems in the neck/shoulder region (Leino & Magni, 1993; Pietri-Taleb et al., 1994).

Only a few studies have investigated the relationship between symptoms of stress/psychological strain and hand/wrist musculoskeletal problems. However, the studies that have been conducted have shown positive findings (Feveile et al., 2002; Leino & Magni, 1993; Macfarlane et al., 2000).

A prospective epidemiological study was needed to investigate whether mental stress reactions increase the risk of developing musculoskeletal disorders (affecting the lower back, neck/shoulders and upper limbs), while controlling for the effects of physical and psychosocial workplace risk factors in a large workforce comprising many occupational groups.

In order to appreciate the role of stress reactions as an intermediary between workplace stressors and WMSDs, a distinction must be made between what researchers believe to be the cause-effect relationship of stress and what lay people believe regarding the role of stress.

Subjective beliefs about stress may influence a person's expectations of what causes stress for themselves and others, and such beliefs are thought to play a part in the reporting or failure to report stress (Furnham, 1997). The resultant behaviour may also affect symptom reporting of WMSDs, however, this has not been researched.

A recent qualitative/quantitative study identified that people possess elaborate beliefs about the causes and consequences of psychosocial work stressors, which subsequently predict psychological well-being and performance (Daniels et al., 2002). Health beliefs are suggested to be better predictors of a person's health behaviour than personality or other individual differences (Furnham, 1988). Personality factors such as neuroticism and other individual psychological differences (positive and negative mood and life satisfaction) have not been adequately researched (Burdorf & Sorock, 1997; Ferguson & Marras, 1997; National Research Council & Institute of Medicine, 2001). Lack of job satisfaction is a factor that may represent an outcome or a risk factor of job stress and has been consistently shown to predict low back problems (Burdorf & Sorock, 1997; National Research Council & Institute of Medicine, 2001).

Rumination is an individual psychological factor that has not been investigated in the musculoskeletal disorder literature. It measures the tendency to think about emotionally upsetting events after they have occurred and has shown a strong relationship to physiological indices of adaptation such as prolonged elevations in urinary-free cortisol secretion following exposure to stress (Roger & Najarian, 1998).

It is plausible that WMSDs may be dependent not only on the degree of exposure to workplace risk factors but also the presence of stress reactions for individuals who may show an increased susceptibility because of individual psychological factors.

The existence of such a relationship could have a serious negative impact for ergonomics interventions that focus on physical and/or psychosocial workplace risk factors for preventing work-related musculoskeletal disorders. Interventions to reduce lifting or hand repetition rates, for example, may result in a 2 to 3-fold reduction in risk. However, despite the reduction in risk, some workers may still continue to experience WMSDs because of other pathological pathways causing musculoskeletal damage, such as individual psychological reactions.

2 WORK UNDERTAKEN IN THE STRESS AND MSD STUDY

The Health & Safety Executive has identified the need for research into the role of stress and other psychological factors upon the development of musculoskeletal disorders.

A prospective epidemiological study had not been conducted that investigated whether mental stress reactions were involved in the development of work-related musculoskeletal disorders affecting the lower back, neck/shoulders or upper limbs. Such a study needed to control for the effects of physical and psychosocial workplace risk factors in a large workforce comprising many occupational groups.

It is necessary to satisfy at least two criteria when addressing causation in epidemiology. The criteria are:-

1. association between exposure and outcome
2. time order, in that the exposure must precede the outcome (Susser, 1991).

Establishing direction (or consequential change) is stated as one of the important criteria but this may not be so important in musculoskeletal disorders research. This is because of the potential evolution of disorders becoming chronic and not abating after exposure to the risk factors has been removed.

The research addressed this need by undertaking a baseline cross-sectional study and follow-up study to determine whether:

1. lay beliefs regarding the causes and alleviation of work stress differ between workers with and without work stress (baseline)
2. interactions between physical and psychosocial work risk factors increase the risk of work stress (baseline)
3. high exposure to physical and psychosocial work risk factors is a predictor of work stress (follow-up)
4. lay beliefs are a predictor of work stress (follow-up)
5. lay beliefs regarding the causes and alleviation of work stress differ between workers with and without self-reported musculoskeletal complaints (baseline)
6. interactions between physical and psychosocial work risk factors increase the risk of self-reported musculoskeletal complaints (baseline)
7. lay beliefs are a predictor of self-reported musculoskeletal complaints (follow-up)
8. high exposure to physical and psychosocial work risk factors is a predictor of self-reported musculoskeletal complaints (follow-up)
9. work stress precedes the onset of self-reported musculoskeletal complaints while controlling for potential exposure interactions and lay beliefs (follow-up).

2.1 THE STRESS AND MSD STUDY

Objectives 1 to 4 were addressed by investigating whether:

- the organisational, physical, psychosocial and individual factors were associated with reporting high perceived job stress in the baseline cross-sectional study (stage I analysis);
- the factors associated with reporting perceived job stress in the stage I analysis also increased the likelihood of reporting high perceived job stress in the follow-up study for workers reporting low to moderate levels of perceived job stress in the baseline cross-sectional study (stage II analysis).

The factors associated with the reporting of high levels of perceived job stress that also preceded and increased the likelihood of onset of high levels of perceived job stress would satisfy the criteria of association and time order indicating involvement in the causation of work-related stress (see section 3 of the report).

Objectives 5-9 were addressed by conducting separate investigations for each of the following musculoskeletal regions:

- self-reported low-back complaints (section 4);
- self-reported upper back complaints (section 5);
- self-reported neck complaints (section 6);
- self-reported shoulder complaints (section 7);
- self-reported forearm/elbow complaints (section 8);
- self-reported hand/wrist complaints (section 9);

For each region, the stage I analysis investigated whether the organisational, physical, psychosocial and individual factors are associated with a musculoskeletal complaint in the baseline cross-sectional study. The stage II analysis for each region investigated whether the factors associated with reporting a musculoskeletal complaint in the stage I analysis also increased the likelihood of reporting a musculoskeletal complaint in the follow-up study for workers not reporting musculoskeletal complaints in the baseline cross-sectional study.

For each region, the factors associated with the reporting of a musculoskeletal complaint that also preceded and increased the likelihood of a new episode would satisfy the criteria of association and time order indicating involvement in the causation of self-reported work-related musculoskeletal complaints.

In the baseline cross-sectional survey, the study population comprised 8000 male and female workers from 20 organisations across 11 industrial sectors in the UK. The study population and the organisations selected were a convenience sample. Part-time workers and workers principally based long term within client organisations were excluded from the study. Male and female workers within the age range of 18-69 years were included in the study.

Workers comprised all 9 major groups from the Standard Occupational Classification 2000. Figure 1 shows the proportion of workers in the working population in England and Wales and the proportion of workers from the study sample spread across the 9 major groups of the Standard Occupational Classification 2000. The study sample had an over-representation of professional workers and an under-representation of skilled trade, personal service, sales customer service and elementary workers. This was partly caused by the different response rates across different occupations.

Figure 2 shows that business and public service associate professionals, science and technology professionals and corporate managers were the largest sub-major groups of the Standard Occupational Classification (2000) represented in the study population.

A response rate of over 60 percent was achieved for 10 of the organisations. The final overall response rate was 54%. However, 15% were returned incomplete, leaving 39% or 3139 persons w ho did complete the questionnaire in the baseline cross-sectional study.

Of the 3139 respondents, about 70% were white-collar workers (office workers, computer operators, technicians etc) and 30% were blue collar workers (delivery drivers, manual handlers, production line workers, oil rig workers etc).

The age and gender difference between the sample population of 3139 and the study population of 8000 were compared between the questionnaire data and information from company records. No significant age or gender differences between the sample population and the study population were observed.

The baseline cross-sectional study questionnaire collected information on demographics, psychosocial work factors, physical work factors, musculoskeletal problems, perceived job stress and other stress reactions and individual trait, attitudes and well-being (see appendix 8 for further information). There were two rounds of reminders for subjects not returning the questionnaire.

The constructs used for measuring psychosocial work factors, individual trait, attitudes and wellbeing had acceptable internal consistency. The questionnaire items used for measuring physical work factors and musculoskeletal outcomes had acceptable measures of agreement (see appendix 8 for further information). A pilot study was conducted using the questionnaire to minimise potential information and response bias by assessing usability and administration methods (see appendix 9 for further information). The questionnaire was also shown in a validation study to be acceptable for classifying workers into low and high physical/psychosocial exposure groups. The musculoskeletal outcome measures were also shown in a validation study to have good to excellent test-retest reliability and were accurate at identifying subjects for inclusion in the study cohort (see appendix 10 for further information).

A follow-up questionnaire was sent to all study participants (N=3139) 14 to 16 months after the baseline cross-sectional study questionnaire was completed. There were two rounds of reminders for subjects not returning the questionnaire.

For the 20 organisations surveyed in the baseline study, 18 returned over 70% of the questionnaires completed in the follow-up study. In fact, the overall response rate for the follow-up study was 86% after excluding leavers from each organisation. Two reminders were sent to non-respondents.

Due to the high response rate in the follow-up study, the possibility of bias due to selective loss of participants was likely to have a small effect on the follow-up results.

Figure 1 The proportion of subjects within the 9 major groups of the Standard Occupational Classification (2000)

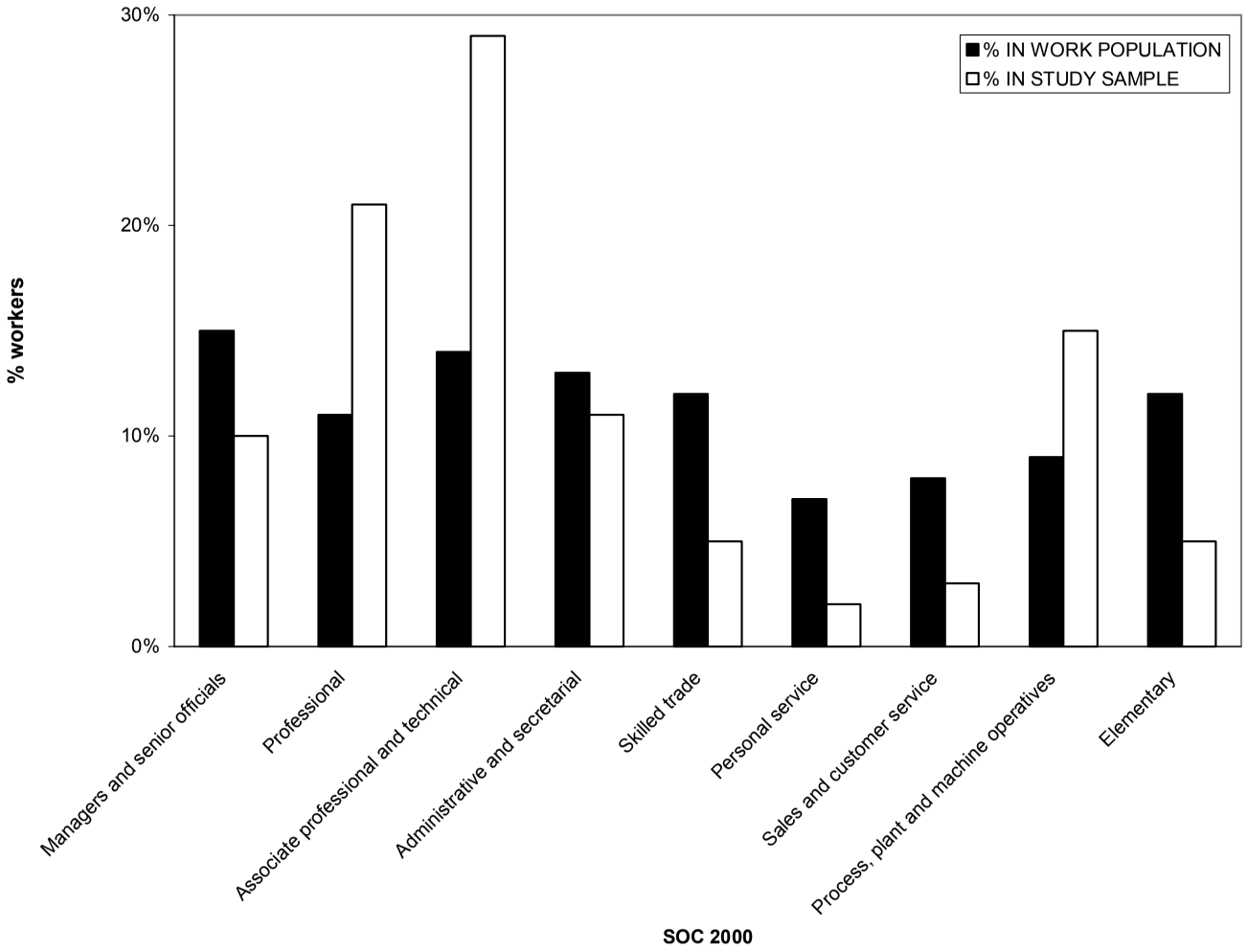
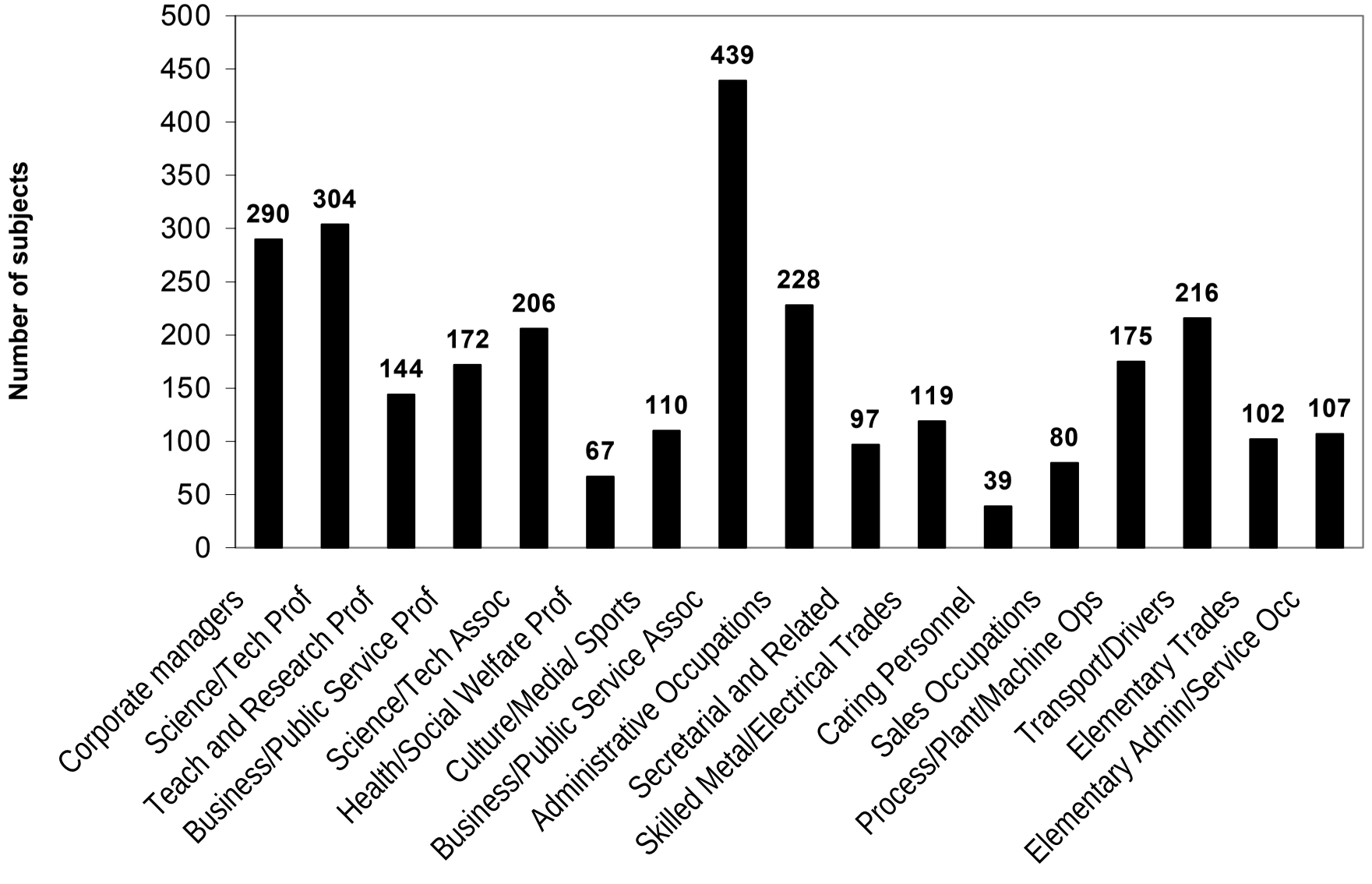


Figure 2. The number of subjects within 17 of the sub-major groups of the Standard Occupational Classification (2000)



2.2 ANALYSES FOR WORK-RELATED STRESS

The single item measure of perceived job stress was used as the outcome. Subjects were asked: In general, how do you find your job? A 5 point likert scale was used: 1 not at all stressful, 2 mildly stressful, 3 moderately stressful, 4 very stressful and 5 extremely stressful. This question has been used in a large epidemiological study of job stress in the UK (Smith et al., 2000).

The analysis strategy was formulated according to the objectives set out in section 2.1.

In stage 1 involving the cross-sectional baseline study data, univariate and multivariate analyses were performed for factors within each of the following domains:

- psychosocial work factors (job demands, decision latitude, social support, extrinsic effort, intrinsic effort, reward, role ambiguity, role conflict, job future ambiguity, verbal abuse, threat of harm/injury)
- work organisation (hours worked, type of hours, travel time to work, shiftwork)
- physical work factors (lifting 6-15 kg greater than 10 times per hour or lifting greater than 16 kg at all, sitting and experiencing vibration more than half the time, always working with back in an awkward position, standing in one position for 30 minutes or more without a break, vibration from a power tool or machine that made the hands vibrate during the past week, repetitive movements of the wrists for much of the normal working day, repeated arm movements, working with head/neck bent or twisted excessively, sitting down on a chair or stool more than half the time, sitting and using a computer more than half the time, using a keyboard for more than four hours during a typical day at work, using a keyboard without a break of over one minute, sitting for 30 minutes or more without a break, working with elbows normally at or below waist height, working with elbows normally at about chest height, working with elbows normally at or above shoulder height, working with the wrists/hands with almost a straight wrist and working with the wrists/hands with a deviated or bent wrist position)
- individual factors (age, gender, neuroticism, rumination, and lay beliefs about the causes and alleviation of stress)

  Lay beliefs about the causes of stress

- stress mainly affects people who have an unsympathetic boss
- people who aren't busy or challenged by their work cannot really experience stress
- people who have just had a promotion can't really be stressed
- people who work for others, or who have to consult colleagues are more stressed because they must constantly follow other people's decisions, routines and ways of working
- men in their 40s/50s can't be stressed because most have already developed their careers and have stable positions
- stress is the result of having to work too fast and in limited amounts of time
- if you enjoy your job, you can't really be stressed by it
- a person is stressed at work usually because he/she has no friends
- stress at work mainly affects people who have to travel frequently or long distances
- a person is stressed mainly because he/she isn't satisfied by his/her job
- stress affects people whose ideas conflict with those of the company
- stress only affects people who aren't their own boss i.e. have to take orders from others
- if an organisation has many young employees, older ones tend to feel threatened by this, which leads to stress
- women are more stressed than men at work because their careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotions
- it is less stressful to be checked upon regularly at work, because this avoids possible mistakes and it is helpful in pointing out expectations

- a woman will be more stressed at work because male attitudes towards female 'bosses' or colleagues create a difficult and constantly challenging climate
- people whose work involves physical danger, like policemen, are often very stressed
- a female employee will be stressed if her boss is too friendly
- the risk of redundancy is a very stressful factor
- the higher the status of the job, the more extensive and disruptive the stress people experience
- if you work with potentially dangerous machines, all you need to do is to be careful and work properly in order not to be greatly stressed
- if a boss is very authoritative, then the job's demands are clearly defined and employees won't become stressed

Lay beliefs about the alleviation of stress

- reducing stress depends on a person's general ability to overcome problems
- that reducing stress depends on whether the person joins other self-help groups for their problems
- reducing stress depends on how hard a person tries
- reducing stress depends on how much self-control the person has
- reducing stress depends on how embarrassed the person feels about having the problem
- reducing stress depends on whether there is something wrong with the person's brain or nervous system
- reducing stress depends on whether the person believes it is possible to eliminate the problem
- reducing stress depends on whether the person seeks out trained medical/psychological help
- reducing stress depends on how much information a person has about the problem
- reducing stress depends on whether the problem is a symptom of some other deep-rooted problem
- reducing stress depends on how lucky a person is
- reducing stress depends on how damaging the problem is to the person's feeling of self-worth and self-esteem
- reducing stress depends on how much eliminating the problem would please others
- reducing stress depends on how much a person stays away from a situation that makes the problem worse

Odds ratios were used to express the ratio of the likelihood of reporting the outcome by comparing the likelihood in the exposed group by the likelihood in the unexposed group. For example, an odds ratio of three is interpreted as meaning that cases with the outcome are three times more likely to have been exposed than cases without the outcome. The estimate of the odds ratio varies within a range of values termed a confidence interval normally reported as 95% confidence intervals (95%CI). It gives an indication of how precisely the odds ratio has been measured, so the 95% confidence interval would indicate that there is a 95% probability that the true odds ratio would lie between the lower and upper value of the confidence interval. The confidence interval is dependent on the magnitude of the estimate, a specified probability of including the true value of the estimate and the sample size in each of the four cells defining exposure and outcome.

The high and low exposure categories for the psychosocial work factors were formed by summing up the number of high exposure items in each factor and dichotomising the sum score. The odds ratio for each stratum of the sum score was calculated for each psychosocial factor to determine the threshold value at which the odds ratio increased above two with a confidence interval greater than one. This threshold was used to classify each worker into low or high exposure group for each psychosocial factor. The low exposure group for each factor was used

as the reference group (OR=1).

For the organisation factors, the hours worked per week was dichotomised about the mean (Standard Deviation 11 hours per week). The high exposure group worked for 42 or more hours per week and the low exposure group worked for up to 41 hours per week. The type of hours was classified by flexible versus fixed hours. Flexible hours being the reference group. The travel time to work was dichotomised about the mean. The high exposure group travelled more than 37 minutes and the low exposure group travelled up to 37 minutes. Work shift was classified by day shift only versus late or night shift. The day shift was used as the reference group.

For the physical work factors, lifting 6-15 kg greater than 10 times per hour or lifting greater than 16 kg at all was classified high exposure. The low exposure group comprised those lifting 6-15 kg less than once per hour or did not perform any lifting tasks at all.

Very frequent (almost continuous) arm movements was classified as high exposure to repeated arm movement. Frequent (regular arm movement with some pauses) and infrequent (some intermittent arm movement) arm movement were classified low exposure and was used as the reference group.

Continuously working with the head/neck bent or twisted excessively was classified as high exposure. Occasionally working or not working with the head/neck bent or twisted excessively was classified as low exposure and was used as the reference group.

Sitting down on a chair or stool for half or more of the working day (about half the time, about three quarters of the time, almost all the time) was classified as high exposure. Sitting down on a chair or stool less than half of the working day (not at all, about a 10th of the time or about a quarter of the time) was classified low exposure and was used as the reference group.

Sitting and using a computer more than half the working day (about half the time, about three quarters of the time, almost all the time) was classified high exposure. Sitting and using a computer less than half of the working day (not at all, about a 10th of the time or about a quarter of the time) was classified low exposure and was used as the reference group.

Sitting and experiencing vibration for half or more of the working day (about half the time, about three quarters of the time, almost all the time was classified high exposure. Sitting less than half of the working day and experiencing vibration (not at all, about a 10th of the time or about a quarter of the time) was classified low exposure and was used as the reference group.

Using a keyboard for four or more hours (4-6 hours or over 6 hours) during a typical day at work was classified high exposure. Using a keyboard for less than four hours during a typical day at work (less than two hours or 2-4 hours) was classified low exposure and was used as the reference group.

Using a keyboard without a break of over one minute for greater than one hour (1-2 hours or over 2 hours) was classified high exposure. Using a keyboard without a break of over one minute for less than one hour (less than 30 minutes or 30 minutes-1 hour) was classified low exposure and was used as the reference group.

For the following items, answering yes was classified high exposure. Answering no to the statement was classified low exposure and was used as the reference group:

- sitting for 30 minutes or more without a break
- working with elbows normally at or below waist height

- working with elbows normally at about chest height
- working with elbows normally at or above shoulder height
- working with the wrists/hands with almost a straight wrist
- working with the wrists/hands with a deviated or bent wrist position
- always or often working with the back in an awkward position
- standing in one position for 30 minutes or more without a break
- vibration from a power tool or machine that made the hands vibrate during the past week
- repetitive movements of the wrists for much of the normal working day

Belief scores about causes and alleviation of stress were dichotomised into those who strongly agreed (≥5 on the 7 point scale) and disagreed with each belief (≤4 on the 7 point scale). Age was classified by over 40 years versus up to 40 years. Up to 40 years being the reference group. Gender was classified female versus male, with male being the reference group. Neuroticism and rumination were formed by summing up the score for each scale and dichotomising the total score into approximately two equal groups. The lower scores were used as the reference group. Those with high scores were more neurotic and ruminated more.

Univariate odds ratios (cOR) for all subjects were calculated with 95% confidence intervals for each factor. Within each domain, the factors with an odds ratio greater than one and a confidence interval not including one (or statistically significant) were included in a multivariate logistic regression model constructed using only the significant factors. Subjects with missing data for all the significant factors within each domain were excluded and the odds ratios re-analysed (sOR) to interpret the effects of missing data on the results. Subjects with no missing data were used in the multivariate logistic regression using the significant factors to produce the adjusted odds ratios (aOR) within each domain.

The factors analysed in the domain specific multivariate regression model that had an odds ratio greater than 1 with a lower confidence limit greater than or equal to 1.00 were entered into a final multivariate logistic regression model (referred to as the final model) constructed across all the domains to identify the smallest number of associated factors. The factors with an odds ratio less than 1 with a high confidence limit less than or equal to 1.00 were also entered into the final model. Age and gender were included in the final model as potential confounders. Correlations between factors in each modelling stage were investigated to identify potential multicollinearity effects.

The final model was examined for epidemiological interactions between physical and psychosocial work factors. Interactions were assessed using departure from an additive model of risk (Kleinbaum et al., 1982) and exemplified by Devereux et al (2002) investigating interactions between physical and psychosocial work risk factors in a previous cross-sectional study. In order to assess the joint effects of exposure variables, four factors were formed for each low/high exposure combination. The physical and psychosocial factors were categorised by summing the number of significant exposure factors in the mixed domain multivariate model to create a sum score for each construct. The odds ratio for each stratum of each sum score was calculated. A sum of zero was used as the reference group. The stratum with a statistically significant rise in the stratum specific odds ratio with a confidence interval greater than one was used as a cut-off for each construct.

The proportion of excess risk (AP) was calculated as the odds ratio for the high physical/high psychosocial exposure group minus the odds ratio for the low physical/high psychosocial exposure group minus the odds ratio for the high physical/low psychosocial exposure group plus one and all divided by the odds ratio for the high physical/high psychosocial exposure group. A corresponding 95% confidence interval was calculated (Hallqvist et al., 1996).

The low exposure group for both variables was used as the reference for calculating the odds ratio in a logistic regression adjusting for age, gender and remaining significant variables from the final mixed domain model.

In stage II, the final logistic regression model was tested using a cohort of subjects who did not report the presence of the outcome at baseline and were followed up to determine outcome status about 14-16 months later.

The baseline study analyses determined association between each factor and the outcome and the prospective study analyses determined time order between each factor and the outcome.

2.3 ANALYSES FOR WORK-RELATED MUSCULOSKELETAL COMPLAINTS

Self reported musculoskeletal complaints were defined by a musculoskeletal problem in the lower back, upper back (the area between the shoulder blades), neck, shoulders, elbow/forearms or hands/wrists which had occurred more than three times or lasting more than 1 week in the previous year (Yes/No).

Separate analyses were performed for each region. The analysis strategy was formulated according to the objectives set out in section 2.1.

In stage 1 involving the cross-sectional baseline study data, univariate and multivariate analyses were performed for factors within each of the following domains:

- psychosocial work factors (job demands, decision latitude, social support, extrinsic effort, intrinsic effort, reward, role ambiguity, role conflict, job future ambiguity, verbal abuse, threat of harm/injury)
- work organisation (hours worked, type of hours, travel time to work, shiftwork)
- physical work factors (lifting 6-15 kg greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position, pushing and pulling with tasks requiring lifting, sitting and experiencing vibration more than half the time, always working with back in an awkward position, standing in one position for 30 minutes or more without a break, vibration from a power tool or machine that made the hands vibrate during the past week, repetitive movements of the wrists for much of the normal working day, repeated arm movements, working with head/neck bent or twisted excessively, sitting down on a chair or stool more than half the time, sitting and using a computer more than half the time, using a keyboard for more than four hours during a typical day at work, using a keyboard without a break of over one minute, sitting for 30 minutes or more without a break, working with elbows normally at or below waist height, working with elbows normally at about chest height, working with elbows normally at or above shoulder height, working with the wrists/hands with almost a straight wrist and working with the wrists/hands with a deviated or bent wrist position)
- individual factors (age, gender, neuroticism, rumination, negative mood, positive mood, life satisfaction and job satisfaction and lay beliefs about the causes and alleviation of stress)

  Lay beliefs about the causes of stress
- stress mainly affects people who have an unsympathetic boss
- people who aren't busy or challenged by their work cannot really experience stress
- people who have just had a promotion can't really be stressed
- people who work for others, or who have to consult colleagues are more stressed because they must constantly follow other people's decisions, routines and ways of working
- men in their 40s/50s can't be stressed because most have already developed their careers and have stable positions

- stress is the result of having to work too fast and in limited amounts of time
- if you enjoy your job, you can't really be stressed by it
- a person is stressed at work usually because he/she has no friends
- stress at work mainly affects people who have to travel frequently or long distances
- a person is stressed mainly because he/she isn't satisfied by his/her job
- stress affects people whose ideas conflict with those of the company
- stress only affects people who aren't their own boss i.e. have to take orders from others
- if an organisation has many young employees, older ones tend to feel threatened by this, which leads to stress
- women are more stressed than men at work because their careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotions
- it is less stressful to be checked upon regularly at work, because this avoids possible mistakes and it is helpful in pointing out expectations
- a woman will be more stressed at work because male attitudes towards female 'bosses' or colleagues create a difficult and constantly challenging climate
- people whose work involves physical danger, like policemen, are often very stressed.
- a female employee will be stressed if her boss is too friendly
- the risk of redundancy is a very stressful factor
- the higher the status of the job, the more extensive and disruptive the stress people experience
- if you work with potentially dangerous machines, all you need to do is to be careful and work properly in order not to be greatly stressed
- if a boss is very authoritative, then the job's demands are clearly defined and employees won't become stressed

Lay beliefs about the alleviation of stress
- reducing stress depends on a person's general ability to overcome problems
- that reducing stress depends on whether the person joins other self-help groups for their problems
- reducing stress depends on how hard a person tries
- reducing stress depends on how much self-control the person has
- reducing stress depends on how embarrassed the person feels about having the problem
- reducing stress depends on whether there is something wrong with the person's brain or nervous system
- reducing stress depends on whether the person believes it is possible to eliminate the problem
- reducing stress depends on whether the person seeks out trained medical/psychological help
- reducing stress depends on how much information a person has about the problem
- reducing stress depends on whether the problem is a symptom of some other deep-rooted problem
- reducing stress depends on how lucky a person is
- reducing stress depends on how damaging the problem is to the person's feeling of self-worth and self-esteem
- reducing stress depends on how much eliminating the problem would please others
- reducing stress depends on how much a person stays away from a situation that makes the problem worse

Individual reactivity measures
- perceived job stress
- perceived life stress
- mental strain

- psychosomatic symptoms
- depression

Odds ratios were used to express the ratio of the likelihood of reporting the outcome by comparing the likelihood in the exposed group by the likelihood in the unexposed group. For example, an odds ratio of three is interpreted as meaning that cases with the outcome are three times more likely to have been exposed than cases without the outcome. The estimate of the odds ratio varies within a range of values termed a confidence interval normally reported as 95% confidence intervals (95%CI). It gives an indication of how precisely the odds ratio has been measured, so the 95% confidence interval would indicate that there is a 95% probability that the true odds ratio would lie between the lower and upper value of the confidence interval. The confidence interval is dependent on the magnitude of the estimate, a specified probability of including the true value of the estimate and the sample size in each of the four cells defining exposure and outcome.

The high and low exposure categories for the psychosocial work factors were formed by summing up the number of high exposure items in each factor and dichotomising the sum score. The odds ratio for each stratum of the sum score was calculated for each psychosocial factor to determine the threshold value at which the odds ratio increased above two with a confidence interval greater than one. This threshold was used to classify each worker into low or high exposure group for each psychosocial factor. The low exposure group for each factor was used as the reference group (OR=1).

For the organisation factors, the hours worked per week was dichotomised about the mean (Standard Deviation 11 hours per week). The high exposure group worked for 42 or more hours per week and the low exposure group worked for up to 41 hours per week. The type of hours was classified by flexible versus fixed hours. Flexible hours being the reference group. The travel time to work was dichotomised about the mean. The high exposure group travelled more than 37 minutes and the low exposure group travelled up to 37 minutes. Work shift was classified by day shift only versus late or night shift. The day shift was used as the reference group.

For the physical work factors, lifting 6-15 kg greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position was classified high exposure. The low exposure group comprised those lifting 6-15 kg less than once per hour or did not perform any lifting tasks at all with or without always/often working with the back in an awkward position. The low exposure group also comprised those lifting 6-15 kg greater than 10 times per hour or lifting greater than 16 kg at all and not always/often working with the back in an awkward position.

Very frequent (almost continuous) arm movements was classified as high exposure to repeated arm movement. Frequent (regular arm movement with some pauses) and infrequent (some intermittent arm movement) arm movement were classified low exposure and was used as the reference group.

Continuously working with the head/neck bent or twisted excessively was classified as high exposure. Occasionally working or not working with the head/neck bent or twisted excessively was classified as low exposure and was used as the reference group.

Sitting down on a chair or stool for half or more of the working day (about half the time, about three quarters of the time, almost all the time) was classified high exposure. Sitting down on a chair or stool less than half of the working day (not at all, about a 10th of the time or about a quarter of the time) was classified low exposure and was used as the reference group.

Sitting and using a computer for half or more of the working day (about half the time, about three quarters of the time, almost all the time) was classified high exposure. Sitting and using a computer less than half of the working day (not at all, about a 10th of the time or about a quarter of the time) was classified low exposure and was used as the reference group.

Sitting and experiencing vibration for half or more of the working day (about half the time, about three quarters of the time, almost all the time was classified high exposure. Sitting less than half of the working day and experiencing vibration (not at all, about a 10th of the time or about a quarter of the time) was classified low exposure and was used as the reference group.

Using a keyboard for more than four hours (4-6 hours or over 6 hours) during a typical day at work was classified high exposure. Using a keyboard for less than four hours during a typical day at work (less than two hours or 2-4 hours) was classified low exposure and was used as the reference group.

Using a keyboard without a break of over one minute for greater than one hour (1-2 hours or over 2 hours) was classified high exposure. Using a keyboard without a break of over one minute for less than one hour (less than 30 minutes or 30 minutes-1 hour) was classified low exposure and was used as the reference group.

For the following items, answering yes was classified as high exposure. Answering no to the statement was classified low exposure and was used as the reference group:

- push and pull objects with tasks requiring lifting
- sitting for 30 minutes or more without a break
- working with elbows normally at or below waist height
- working with elbows normally at about chest height
- working with elbows normally at or above shoulder height
- working with the wrists/hands with almost a straight wrist
- working with the wrists/hands with a deviated or bent wrist position
- always or often working with the back in an awkward position
- standing in one position for 30 minutes or more without a break
- vibration from a power tool or machine that made the hands vibrate during the past week
- repetitive movements of the wrists for much of the normal working day

Belief scores about causes and alleviation of stress were dichotomised into those who strongly agreed ($\geq$5 on the 7 point scale) and disagreed with each belief ($\leq$4 on the 7 point scale). Age was classified by over 40 years versus up to 40 years. Up to 40 years being the reference group. Gender was classified female versus male, with male being the reference group. Neuroticism, rumination, positive mood, negative mood and life satisfaction were formed by summing up the score for each scale and dichotomising the score into approximately two equal groups. The lower scores were used as the reference group. Those with high scores were more neurotic, ruminated more, had a more positive mood, had a more negative mood and had greater life satisfaction. Job satisfaction was formed by summing up the number of items with the highest score (3) in each factor and dichotomising the sum score. A score of 2 or more was classified as a high score. A high score indicated low job satisfaction.

Perceived job stress was measured using a single item. Subjects were asked: In general, how do you find your job? A 5 point likert scale was used: 1 not at all stressful, 2 mildly stressful, 3 moderately stressful, 4 very stressful and 5 extremely stressful. A cut off score of 4 or 5 was used to classify workers into two groups. For perceived life stress, psychosomatic symptoms and depression, the sum score was dichotomised into approximately two equal groups. For mental strain, the GHQ12 scores were dichotomised by using a standard cut-off score of 3.

Univariate odds ratios (cOR) for all subjects were calculated with 95% confidence intervals for each factor. Within each domain, the factors with an odds ratio greater than one and a confidence interval not including one (or statistically significant) were included in a multivariate logistic regression model constructed using only the significant factors. Subjects with missing data for all the significant factors within each domain were excluded and the odds ratios re-analysed (sOR) to interpret the effects of missing data on the results. Subjects with no missing data were used in the multivariate logistic regression using the significant factors to produce the adjusted odds ratios (aOR) within each domain to identify confounding effects. The presence of collinearity was checked by assessing the correlations in the multivariate analyses.

The factors analysed in the domain specific multivariate regression model that had an odds ratio greater than 1 with a lower confidence limit greater than or equal to 1.00 were selected for inclusion into the final multivariate logistic regression model constructed across all the domains. The factors with an odds ratio less than 1.00 with a high confidence limit less than or equal to 1.00 were also entered into the final model. Age and gender were included in the final model as potential confounders.

In order to assess the joint effects of the physical and psychosocial exposure factors, four indicator variables were formed for each low/high exposure combination. That is:-

- low physical-low psychosocial exposure
- low physical-high psychosocial exposure
- high physical-low psychosocial exposure
- high physical-high psychosocial exposure

The physical and psychosocial exposure indicator variables were categorised by summing the number of significant physical exposure factors and the number of significant psychosocial exposure factors to create a sum score for each variable. The odds ratio for each stratum of each sum score was calculated. The stratum with a statistically significant rise in the stratum specific odds ratio with a confidence interval greater than one was used as a cut-off for the physical and psychosocial exposure variables. The four indicator variables were then created.

The model was examined for epidemiological interactions between physical and psychosocial work factors. Interactions were assessed using departure from an additive model of risk (Kleinbaum et al., 1982) and exemplified by Devereux et al (2002) investigating interactions between physical and psychosocial work risk factors in a previous cross-sectional study. To test for epidemiological interaction between two factors, workers reporting high exposure to both or either set of physical and psychosocial exposure factors were contrasted to a reference group reporting low exposure to both sets of exposure factors.

The proportion of excess risk (AP) was calculated as the odds ratio for the high physical/high psychosocial exposure group, minus the odds ratio for the low physical/high psychosocial exposure group, minus the odds ratio for the high physical/low psychosocial exposure group plus one and all divided by the odds ratio for the high physical/high psychosocial exposure group. A corresponding 95% confidence interval was calculated (Hallqvist et al., 1996).

The low exposure group for both variables was used as the reference for calculating the odds ratio in a logistic regression adjusting for age, gender and remaining significant variables from the work organisation and individual domains.

In stage II, all the factors in the logistic regression model of stage I were tested using a cohort of subjects who did not report the presence of the outcome at baseline and were followed up to determine outcome status about 14-16 months later. This was done to test whether the factors

associated with the outcome also predicted the onset of the outcome.

To test whether work stress precedes the onset of self-reported musculoskeletal complaints while controlling for potential exposure effects, the univariate odds ratio and 95% confidence interval was calculated for each of the individual reactivity factors (perceived job stress, perceived life stress, mental strain, psychosomatic symptoms and depression). Each individual reactivity factor was then entered into a multivariate logistic regression model and adjusted for age, gender and the physical and psychosocial exposure combinations to determine which individual reactivity measures may be potential predictors.

A number of logistic regression models were used to construct a full model containing each physical-psychosocial exposure combination, age, gender, perceived job stress, perceived life stress and other individual reactivity measures that were potential predictor factors. The first model contained each physical-psychosocial exposure combination term, age and gender. Perceived job stress and life stress were then entered into the second model. This procedure made it possible to determine whether the odds ratios for each exposure combination were mainly influenced by adjustment for the group of factors at each modelling stage.

All analyses were performed using SPSS (SPSS Inc. SPSS for Windows release 11.5, Illinois, U.S.A.).

3 WORK-RELATED STRESS

Work organisation, psychosocial work factors, individual factors (demographic, trait and attitude) and physical factors are domains that have all been implicated in the development of work-related stress.

The analyses in this section are split into two stages. The stage I analyses were conducted to investigate whether organisational, physical, psychosocial or individual factors were associated with reporting high perceived job stress in the baseline cross-sectional study. The stage II analyses were conducted to investigate whether the factors associated with reporting perceived job stress in stage I also increased the likelihood of reporting high perceived job stress in the follow-up study of workers reporting low to moderate levels of perceived job stress in the baseline cross-sectional study.

The factors associated with the reporting of high levels of perceived job stress that also preceded and increased the likelihood of onset of high levels of perceived job stress would satisfy the criteria of association and time order indicating possible involvement in the causation of work-related stress.

The outcome measure (correlated with both stressors and psychological/physiological reactions) was used to describe a subjective perception of a process whereby a worker is exposed to stressors and is likely to experience acute reactions (Smith et al., 2000).

Of the 3139 subjects responding to the baseline study questionnaire, 3106 reported a rating on perceived job stress. Figure 3 shows that 12% reported their job as very or extremely stressful. For the purposes of the analyses, these workers were classified with high perceived job stress. The remaining 88% of workers reported that the work was mildly or moderately stressful or not stressful at all and were classified with low perceived job stress, according to Smith et al. 2000.

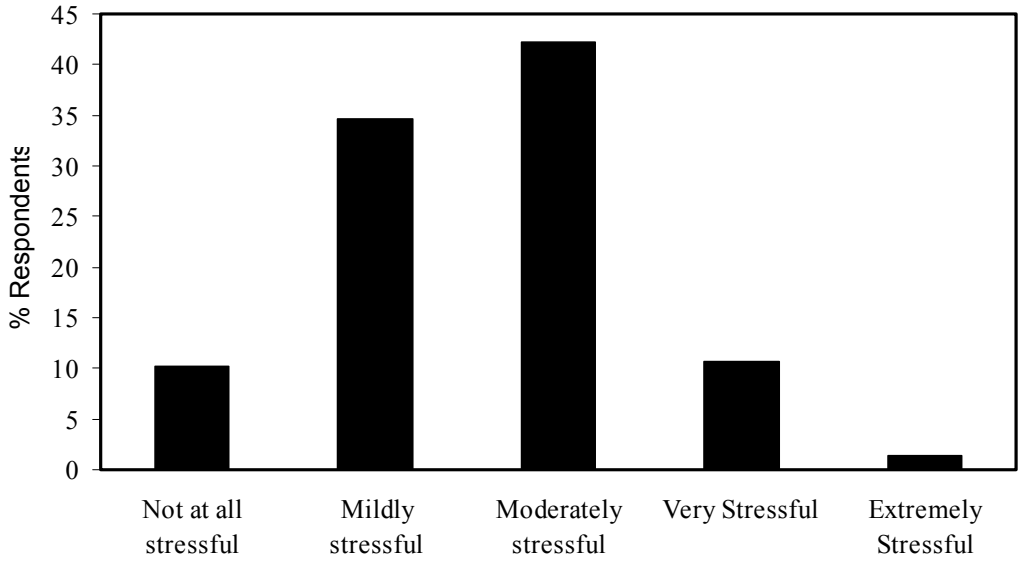


Figure 3 The proportion of workers reporting how stressful they find their job

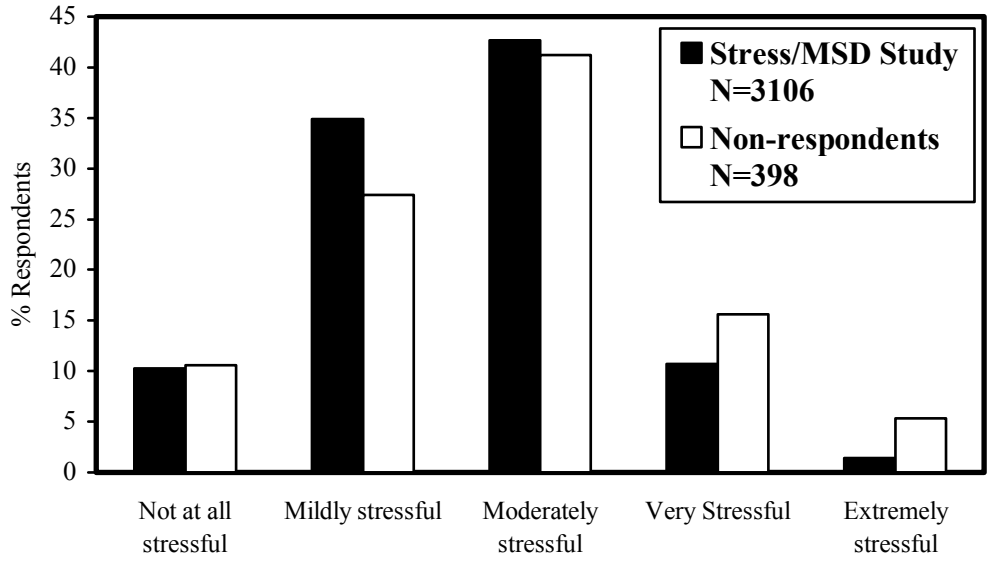


Figure 4 Perceived job stress between respondents and non-respondents

Non-respondents to the questionnaire used in the baseline cross-sectional study were sent a checklist to identify whether they experienced perceived job stress and whether they differed with respect to their job demands. Figure 4 shows that respondents reported less high job stress compared to the 398 non-respondents from the study sample that returned the checklist. The lower prevalence in the sample population and the indication that non-respondents did not differ in their job demands suggested that it would be harder to detect a true effect of perceived job stress in the cross-sectional baseline study if it existed.

3.1 STAGE I ANALYSES FOR WORK-RELATED STRESS

Referring to table 1 in appendix 1, high job demands, low decision latitude, low social support, high extrinsic effort, high intrinsic effort, low reward, high role ambiguity, high role conflict, high job future ambiguity, frequent verbal abuse and the frequent threat of harm/injury were psychosocial work factors univariately associated with high perceived job stress. The exclusion of cases with missing data had little effect on the association between each psychosocial work risk factor and the outcome.

After adjustment for the effects of each factor upon the other, all factors were strongly associated with perceived job stress except for social support, reward and job future ambiguity. A tentative increase in the likelihood was observed for these factors and were excluded in the final mixed domain model. Job demands was not included in the mixed domain model because of potential overlap with extrinsic effort. Extrinsic effort had the strongest univariate odds ratio and was therefore retained in the mixed domain model. A considerable reduction was observed between the univariate and multivariate odds ratios for each factor. This suggested inter-relationships between the factors.

Referring to table 2 in appendix 1, the number of hours normally worked per week and working a late or night shift were organisation factors univariately associated with high perceived job stress with an odds ratio and confidence interval indicating a true effect. Working fixed compared to flexible hours and travel time to work had only a tentative univariate association

with the outcome and were excluded from subsequent analyses. The exclusion of cases with missing data had little effect on the association between hours worked or shift-work and the outcome.

After adjustment for the effects of each factor upon the other, hours worked and shift-work were strongly associated with perceived job stress.

The following physical work factors had weak univariate associations with perceived job stress and were excluded in subsequent analyses:-

- sitting down on a chair or stool more than half the time
- sitting and using a computer more than half the time
- using a keyboard for more than four hours during a typical day at work
- using a keyboard without a break of over one minute
- sitting for 30 minutes or more without a break
- working with elbows normally at or below waist height
- working with elbows normally at about chest height
- working with elbows normally at or above shoulder height
- working with the wrists/hands with almost a straight wrist
- working with the wrists/hands with a deviated or bent wrist position.

Referring to table 3 in appendix 1, physical work factors univariately associated with high perceived job stress with an odds ratio and confidence interval indicating a true effect were:-

- lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all
- sitting and experiencing vibration more than half the time
- always working with the back in an awkward position
- standing in one position for 30 minutes or more without a break
- vibration from a power tool or machine that made the hands vibrate during the past week
- repetitive movements of the wrists for much of the normal working day
- almost continuously repeated arm movements
- and working with their head/neck bent or twisted excessively

The exclusion of cases with missing data for these factors had little effect on the odds ratios. After adjustment for the effects of each factor upon the other, always working with the back in an awkward position was the only factor with an odds ratio and confidence interval indicating a true effect.

A tentative increase in the likelihood was observed for standing in one position for 30 minutes or more without a break, vibration from a power tool and working with their head/neck bent or twisted excessively. The remaining factors were unlikely to be associated with the outcome and did not meet the inclusion criteria for the final mixed model.

Referring to table 4 in appendix 1, age and high scores on neuroticism and rumination (neurotics and ruminators) were univariately associated with high perceived job stress with an odds ratio and confidence interval indicating a true effect. Gender (females compared to males) did not have a univariate association with the outcome but remained in subsequent analyses as a potential confounder. The exclusion of cases with missing data had little effect on the odds ratios. After adjustment for the effects of each factor upon the other, age, neuroticism and rumination were strongly associated with perceived job stress.

The following lay beliefs about the causes of stress had weak univariate associations with perceived job stress and were excluded in subsequent analyses:-

- stress at work mainly affects people who have to travel frequently or long distances

- a person is stressed mainly because he/she isn't satisfied by his/her job
- stress affects people whose ideas conflict with those of the company
- stress only affects people who aren't their own boss i.e. have to take orders from others
- if an organisation has many young employees, older ones tend to feel threatened by this, which leads to stress
- women are more stressed than men at work because their careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotions
- it is less stressful to be checked upon regularly at work, because this avoids possible mistakes and it is helpful in pointing out expectations
- a woman will be more stressed at work because male attitudes towards female 'bosses' or colleagues create a difficult and constantly challenging climate
- people whose work involves physical danger, like policemen, are often very stressed
- a female employee will be stressed if her boss is too friendly
- the risk of redundancy is a very stressful factor
- the higher the status of the job, the more extensive and disruptive the stress people experience
- if you work with potentially dangerous machines, all you need to do is to be careful and work properly in order not to be greatly stressed
- if a boss is very authoritative, then the job's demands are clearly defined and employees won't become stressed (appendix 1, table 5)

The lay beliefs about causes of stress univariately associated with high perceived job stress, with an odds ratio and confidence interval indicating a true effect, were:-

- stress mainly affects people who have an unsympathetic boss
- people who aren't busy or challenged by their work cannot really experience stress
- people who have just had a promotion can't really be stressed
- people who work for others, or who have to consult colleagues are more stressed because they must constantly follow other people's decisions, routines and ways of working
- men in their 40s/50s can't be stressed because most have already developed their careers and have stable positions
- stress is the result of having to work too fast and in limited amounts of time
- if you enjoy your job, you can't really be stressed by it
- a person is stressed at work usually because he/she has no friends (appendix 1, table 6).

The exclusion of cases with missing data for these factors had little effect on the odds ratios. After adjustment for the effects of each factor upon the other, the only factors with an odds ratio and confidence interval indicating a true effect were:-

- people who work for others, or who have to consult colleagues are more stressed because they must constantly follow other people's decisions, routines and ways of working
- stress is the result of having to work too fast and in limited amounts of time
- stress mainly affects people who have an unsympathetic boss
- a person is stressed at work usually because he/she has no friends.

The following lay beliefs about the alleviation of stress had weak univariate associations with perceived job stress and were excluded in subsequent analyses:-

- reducing stress depends on how hard a person tries
- reducing stress depends on how much self-control the person has
- reducing stress depends on how embarrassed the person feels about having the problem
- reducing stress depends on whether there is something wrong with the person's brain or nervous system
- reducing stress depends on whether the person believes it is possible to eliminate the problem
- reducing stress depends on whether the person seeks out trained medical/psychological help
- reducing stress depends on how much information a person has about the problem
- reducing stress depends on whether the problem is a symptom of some other deep-rooted problem
- reducing stress depends on how lucky a person is
- reducing stress depends on how damaging the problem is to the person's feeling of self-worth and self-esteem
- reducing stress depends on how much eliminating the problem would please others
- reducing stress depends on how much a person stays away from a situation that makes the problem worse (appendix 1, table 7).

The lay beliefs about alleviation of stress univariately associated with high perceived job stress, with an odds ratio and confidence interval indicating a true effect, were:-

- reducing stress depends on a person's general ability to overcome problems
- reducing stress depends on whether the person joins other self-help groups for their problems

A strong belief in these two factors resulted in a reduced likelihood of reporting perceived job stress OR 0.55 (95% CI 0.44-0.68) and OR 0.71 (95% CI 0.54-0.92) respectively. The exclusion of cases with missing data for these factors had little effect on the odds ratios. After adjustment for all other individual demographic, trait and attitude factors, the adjusted odds ratios were OR 0.58 (95% CI 0.45-0.74) and OR 0.63 (95% CI 0.46-0.85) respectively, i.e. very little change.

Out of all the individual factors analysed, age, gender, neuroticism, rumination and the following lay beliefs were included in the final model shown in table 1:-

- people who work for others, or who have to consult colleagues are more stressed because they must constantly follow other people's decisions, routines and ways of working
- stress is the result of having to work too fast and in limited amounts of time
- stress mainly affects people who have an unsympathetic boss
- a person is stressed at work usually because he/she has no friends
- reducing stress depends on a person's general ability to overcome problems
- reducing stress depends on whether the person joins other self-help groups for their problems.

Table 1 Comparing the likelihood of perceived job stress for all subjects at baseline (N=2606) and for the cohort at follow-up (N=1505) who did not report perceived job stress at baseline for all variables in the mixed domain model

	Baseline study		***Follow-up study***	
	aOR	***(95% CI)***	***aOR***	***(95% CI)***
Hours worked per week	1.69	1.24-2.29	1.21	0.80-1.82
Shift-work	1.12	0.80-1.56	0.85	0.52-1.38
Extrinsic effort	3.70	2.60-5.29	2.03	1.32-3.11
Intrinsic effort	2.70	1.93-3.80	2.11	1.39-3.20
Role conflict	2.04	1.45-2.86	1.77	1.17-2.68
Role ambiguity	1.53	1.13-2.07	1.36	0.91-2.03
Verbal abuse or confrontations with clients/public	1.46	1.04-2.07	1.96	1.20-3.19
Threat of physical harm or injury	1.43	0.92-2.22	1.14	0.56-2.31
Decision latitude	1.28	0.92-1.79	0.91	0.55-1.50
Always or often working with the back in an awkward position	1.32	0.97-1.81	1.11	0.70-1.74
Age	1.44	1.08-1.91	1.23	0.84-1.80
Gender	1.22	0.89-1.67	1.24	0.82-1.88
Neuroticism	1.78	1.28-2.47	0.81	0.53-1.24
Rumination	1.54	1.10-2.16	1.56	0.93-2.60
The belief that people who work for others, or who have to consult colleagues are more stressed because they must constantly follow other people's decisions, routines and ways of working	1.52	1.11-2.07	0.97	0.62-1.53
The belief that stress is the result of having to work too fast and in limited amounts of time	1.41	1.01-1.96	1.23	0.79-1.90
The belief that reducing stress depends on a person's general ability to overcome problems	0.63	0.48-0.85	0.87	0.58-1.30
The belief that reducing stress depends on whether the person joins other self-help groups for their problems	0.63	0.44-0.91	0.75	0.47-1.21
The belief that stress only affects people who have an unsympathetic boss	1.19	0.88-1.60	1.06	0.71-1.59
The belief that a person is stressed at work usually because he/she has no friends	0.69	0.47-1.01	1.08	0.66-1.77

All the factors from the organisational, physical, psychosocial and individual domains with adjusted domain-specific odds ratios and confidence intervals indicating a true effect were included in a mixed domain regression model shown in table 1.

Referring to the adjusted odds ratios of the baseline study, the number of hours normally worked per week was the only organisation factor strongly associated with reporting high perceived job stress. Working a late or night shift had a tentative association with the outcome.

Extrinsic effort, intrinsic effort, role conflict, role ambiguity and verbal abuse and/or confrontations with clients or the general public were psychosocial work factors strongly associated with reporting high perceived job stress. There was over a twofold increase in the likelihood of perceived job stress if highly exposed to extrinsic and intrinsic effort and role conflict. Decision latitude and the threat of physical harm or injury was tentatively associated with the outcome.

Always or often working with the back in an awkward position was the only physical work factor included in the mixed domain multivariate model. However, the odds ratio and confidence interval indicated a tentative association with the outcome.

Neuroticism, rumination and age were associated with an increased likelihood of reporting high perceived job stress but not gender. Two out of four lay beliefs about the causes of stress indicated a true effect in the mixed domain model (belief about work demands and autonomy). Both lay beliefs about the alleviation of stress (beliefs about overcoming problems and joining self-help groups) reduced the likelihood of reporting high perceived job stress. The odds ratio and confidence intervals indicated a true effect for both factors.

Different combinations of exposure to physical and psychosocial work risk factors are shown in the regression model of Table 2. Always or often working with the back in an awkward position was used to form the physical exposure variable. The psychosocial exposure variable was formed by summing the number of high exposure variables for extrinsic effort, intrinsic effort, role ambiguity, role conflict and verbal abuse or confrontations with clients or the general public (psychosocial work risk factors according to the model in table 1). A significant rise in the stratum specific odds ratio with a confidence interval greater than one was used as a cut-off for classifying low and high exposure groups for the combined effects of psychosocial work risk factors. Workers exposed to three or more of the psychosocial work risk factors were classified high exposure. Those exposed to two or less psychosocial work risk factors were classified low exposure.

Table 2 Odds ratios and 95% confidence interval for perceived job stress by different combinations of exposure to physical and psychosocial work risk factors reported at baseline. Odds ratios are adjusted for all other associated variables in table 1

	aOR	***(95% CI)***
Low physical-low psychosocial exposure	1.00	-
High physical-low psychosocial exposure	1.76	1.00-3.10
Low physical-high psychosocial exposure	6.55	4.50-9.52
High physical-high psychosocial exposure	9.18	6.08-13.86

Workers with high exposure to both physical and psychosocial work risk factors were about 9 times more likely to report perceived job stress compared to workers with low exposure to both sets of factors. Workers with low exposure to the physical work risk factor and high exposure to psychosocial work risk factors were about 7 times more likely to report perceived job stress. Workers with high exposure to the physical work risk factors and low exposure to psychosocial work risk factors were 1.76 times more likely to report perceived job stress.

High exposure to both physical and psychosocial workplace risk factors increased the likelihood of reporting perceived job stress by the greatest amount. There was also a potential interaction effect between physical and psychosocial workplace risk factors (AP=0.20 95%CI -0.06-0.47).

Summarising the results of the stage 1 analysis, organisation, psychosocial and individual factors (age, traits and attitudes) were strongly associated with workers reporting high perceived job stress. Physical work factors were not strongly but tentatively associated with the outcome. However, workers exposed to a combination of physical and psychosocial risk factors had the greatest likelihood of reporting high perceived job stress. The stage II analysis was conducted in order to determine whether these factors and the combined effects predicted the reporting of perceived job stress.

3.2 STAGE II ANALYSES FOR WORK-RELATED STRESS

For the stage II analysis on work-related stress, the cohort (N=1823) who reported no to moderate levels of job stress in the baseline cross-sectional survey were included in the cohort that were followed-up 14 months later. The cumulative incidence of high perceived job stress in the cohort was 6.3%.

Table 1 shows a comparison between the multivariate adjusted odds ratios obtained at the cross-sectional baseline study compared to the follow-up study.

Referring to the adjusted odds ratios in the follow-up study in table 1, extrinsic effort, intrinsic effort, role conflict and verbal abuse or confrontations with clients or the general public increased the likelihood of reporting high perceived job stress at follow-up. The odds ratios and confidence intervals indicated a true effect for these factors.

High exposure to these factors was associated with high perceived job stress for workers in the baseline study and was also the predictor of the onset of perceived job stress in the cohort without the outcome in the baseline study.

Always or often working with the back in an awkward position had a tentative association with high perceived job stress and was also a tentative predictor. The odds ratio for the high physical-high psychosocial exposure group was 4.10 (95% CI 2.34-7.19) suggesting that high exposure to both physical and psychosocial work risk factors predicted the onset of high perceived job stress. However, the low physical-high psychosocial exposure group had an odds ratio of 3.71 (95%CI 2.38-5.80). The odds ratio for the low physical-high psychosocial exposure group was 1.35 (95%CI 0.67-2.71). This indicates that high exposure to a combination of psychosocial workplace risk factors is the main predictor of high perceived job stress.

Age, neuroticism and the lay beliefs that people who work for others are more stressed and stress is the result of having too many work pressures were associated with perceived job stress in the baseline cross-sectional study. However, these factors did not predict the onset of high perceived job stress in the follow-up study. A high score on rumination was associated with

perceived job stress and it was a tentative predictor in the follow-up analysis. Gender did not increase the likelihood in the baseline cross-sectional study or the follow-up study.

3.3 CONCLUSIONS ON WORK-RELATED STRESS

The psychosocial work factors - extrinsic effort, intrinsic effort, role conflict and verbal abuse or confrontations with clients or the general public - were not only associated with high perceived job stress but also predicted the onset of this outcome.

High exposure to both physical and psychosocial work risk factors produced the greatest likelihood of reporting high perceived job stress compared to other combinations of exposure to these sets of workplace risk factors. There was a potential interaction effect between high exposure to physical and psychosocial work risk factors that increased the likelihood of reporting high perceived job stress. The increase in the likelihood of reporting the onset of high perceived job stress was mainly from high exposure to a number of psychosocial workplace risk factors.

Age, neuroticism, rumination and the lay beliefs about stress being the result of work pressure and having to work for others were associated with high perceived job stress. However, there was no evidence from these findings that these individual factors predicted high perceived job stress. Association and time order were not observed. However, it should be noted that rumination showed a tentative increase in the likelihood of reporting the onset of high perceived job stress and also showed an association with the outcome in the baseline cross-sectional study.

4 SELF-REPORTED LOW-BACK COMPLAINTS

Factors within the work organisation domain, the psychosocial work domain, individual domain (demographic, trait and attitude), the physical work domain and individual reactivity have all been implicated in the development of self-reported musculoskeletal complaints.

The analyses in this section are split into two stages. The stage I analyses were conducted to investigate whether organisational, physical, psychosocial or individual factors were associated with reporting self-reported low-back complaints in the baseline cross-sectional study. The stage II analyses were conducted to investigate whether the factors associated with self-reported low-back complaints in stage I also increased the likelihood of reporting this outcome in the follow-up study of workers who did not report low-back complaints in the baseline cross-sectional study. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

The factors associated with the reporting of low-back complaints that also preceded and increased the likelihood of reporting new episodes would satisfy the criteria of association and time order indicating involvement in the causation of this outcome.

Of the 3139 subjects responding to the baseline study questionnaire, 3037 reported a rating on low-back problems, defined as having problems more than three times or lasting more than one week in the previous year. About 28% reported such a problem, of which approximately:-

- 50% reported separate episodes of the low-back problems in the last year with a frequency of at least once a month.
- 40% reported that low-back problems lasted between one day and one week, 20% experienced episodes which lasted more than one week and 7% more than one month.
- 50% experienced a low-back problem in the last seven days.
- 60% reported that symptoms were not present when they first started the present job.
- 25% rated their pain right now between three and five, on a pain scale with a score of five indicating intolerable pain and a score of one indicating no pain.
- 40% reported that pain or discomfort in the low-back extended into the legs. Of these, 43% reported pain or discomfort in the buttocks, 65% in the thigh, 30% in the lower leg, and 16% in the foot.
- 25% reported an injury to the low-back due to a slip or fall.
- 50% had gone for treatment for the lower back problem in the last year.
- 3.5% had surgery for this problem.
- 30% had missed work in the last year for at least one day due to the problem.
- 20% had to perform light or restricted work in the last year because of their low-back problem.
- 32% reported difficulty maintaining their normal work pace because of their problem.
- 57% reported that specific activities at work made the problem worse.

The outcome measure for self-reported low-back problems also included workers who experienced chronic and acute low-back problems with serious neural pathology, who sought medical attention and required work absence, restricted duty or had difficulty performing work.

4.1 STAGE I ANALYSES FOR SELF-REPORTED LOW-BACK COMPLAINTS

This section describes the results of the domain specific regression models and the factors selected for inclusion into the mixed domain model.

Referring to the crude odds ratios in table 1 in appendix 2, high job demands, low decision latitude, low social support, high extrinsic effort, high intrinsic effort, low reward, high role conflict, high job future ambiguity, frequent verbal abuse and the frequent threat of harm/injury were psychosocial work factors univariately associated with self-reported low-back complaints. A tentative increase in the likelihood was observed for high role ambiguity and so was excluded from subsequent analyses. The exclusion of cases with missing data had little effect on the association between each psychosocial work risk factor and the outcome.

After adjustment for the effects of each factor upon the other (refer to the adjusted odds ratios in table 1 in appendix 2), high exposure to extrinsic effort, intrinsic effort, role conflict and a threat of physical harm or injury was associated with self-reported low-back complaints. These factors were included in the mixed domain model.

A tentative increase in the likelihood was observed for social support, reward, job future ambiguity and verbal abuse. Job demands and decision latitude were unlikely to be risk factors, and so they were excluded in the mixed domain model. A considerable reduction was observed between the crude and adjusted odds ratios for each factor. This suggested inter-relationships between the psychosocial work factors.

Referring to table 2 in appendix 2, the number of hours normally worked per week and working a late or night shift were organisation factors univariately associated with self-reported low-back complaints, with a crude odds ratio and confidence interval indicating a true effect. Working fixed as opposed to flexible hours and travel time to work were unlikely to be risk factors and were excluded from subsequent analyses. The exclusion of cases with missing data had little effect on the association between hours worked or shift-work and the outcome.

After adjustment for the effects of each factor upon the other, hours worked and shift-work were associated with self-reported low-back complaints. These factors were included in the mixed domain model.

Referring to table 3 in appendix 2, the following physical work factors had tentative univariate associations with self-reported low-back complaints and were excluded in subsequent analyses:-

- sitting and experiencing vibration more than half the time
- sitting for 30 minutes or more without a break.

Physical work factors univariately associated with self-reported low-back complaints with a crude odds ratio and confidence interval indicating a true effect were:-

- lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position
- pushing and pulling objects combined with tasks requiring lifting
- standing in one position for 30 minutes or more without a break
- vibration from a power tool or machine that made the hands vibrate during the past week.

The exclusion of cases with missing data for these factors had little effect on the odds ratios. After adjustment for the effects of each factor upon the other, only the two lifting factors had an adjusted odds ratio and confidence interval indicating a true effect. These factors were included in the mixed domain model.

A tentative increase in the likelihood was observed for vibration from a power tool. Standing in one position for 30 minutes or more without a break was unlikely to be associated with the outcome. These two factors were not included in the mixed domain model.

Referring to table 4 in appendix 2, age, high scores on neuroticism, rumination, positive and negative effect (individual trait factors), life and job satisfaction (individual well-being factors) were univariately associated with self-reported low-back complaints. Being satisfied with your life and having a positive mood reduced the likelihood of self-reporting low-back complaints. Not being satisfied with your job increased the likelihood. Gender (females compared to males) did not have a univariate association with the outcome but remained in subsequent analyses as a potential confounder.

Referring to table 5 in appendix 2, the lay beliefs about causes and alleviation of stress univariately associated with self-reported low-back complaints were:-

- a person is stressed mainly because he/she isn't satisfied by his/her job
- people who have just had a promotion can't really be stressed
- people whose work involves physical danger, like policemen, are often very stressed
- if a boss is very authoritative, then the job's demands are clearly defined and employees won't become stressed
- reducing stress depends on whether the person seeks out trained medical/psychological help
- reducing stress depends on how much a person stays away from a situation that makes the problem worse.

The exclusion of cases with missing data had little effect on the odds ratios. After adjustment for the effects of each factor (demographics, traits, attitudes and well-being factors) upon the other, only age, not being satisfied with your job and the subjective belief that reducing stress depends on how much a person stays away from a situation that makes the problem worse were associated with self-reported low-back complaints. These factors were included in the mixed domain model.

The psychosocial work risk factors that remained significant in the domain-specific multivariate model (extrinsic effort, intrinsic effort, role conflict and a threat of physical harm or injury) were used to create a psychosocial exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 3 or more factors).

The physical work risk factors that remained significant in the domain-specific multivariate model (lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position, pushing and pulling objects combined with tasks requiring lifting) were used to create a physical exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 factors).

The physical and psychosocial exposure variables were used to create four indicator variables for different combinations of exposure to physical and psychosocial work risk factors and are shown in the mixed domain model in table 3.

The mixed domain model shown in table 3 identifies the smallest number of factors associated with self-reported low-back complaints. None of the organisational factors, i.e. the hours worked per week or shift-work, were associated with the outcome.

Workers highly exposed to psychosocial work risk factors and not physical work risk factors

were 1.7 times more likely to report low-back complaints compared to workers with low exposure to both of these factors.

Workers highly exposed to physical work risk factors and not to psychosocial work risk factors were approximately twice as likely to report low-back complaints compared to workers without high exposure to either physical or psychosocial work risk factors.

The greatest likelihood of reporting low-back complaints was for workers highly exposed to both physical and psychosocial work risk factors. They were four times more likely to report problems compared to workers exposed to neither set of factors. The confidence interval for the adjusted odds ratios for each exposure group suggested a true effect.

Furthermore, a tentative epidemiological interaction effect was observed between physical and psychosocial work risk factors indicated by a departure from an additive model of risk (AP=0.24 95%CI -0.07-0.54).

The only individual factors significantly associated with self-reported low-back complaints were age and low job satisfaction. Gender and the lay belief about the alleviation of stress were unlikely true effects.

Summarising the results of the stage 1 analysis using the data from the baseline cross-sectional study, physical, psychosocial workplace factors and individual factors (age and low job satisfaction) were strongly associated with workers reporting low-back complaints. The combined effects of exposure to physical and psychosocial work risk factors increased the likelihood of reporting the outcome.

4.2 STAGE II ANALYSES FOR SELF-REPORTED LOW-BACK COMPLAINTS

The stage I analyses showed the factors associated with self-reported low back complaints. The stage II analyses in this section were conducted in order to determine whether the factors associated with self-reported low-back complaints in the stage I analyses also predicted new episodes of self-reported low back problems. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

In the baseline cross-sectional study, workers who did not report having low-back problems in the last 12 months were selected for the follow-up cohort (1637 workers). In total, 1182 (72%) responded to the follow-up questionnaire 14 months later and were included in the prospective data analysis. The cumulative incidence of self-reported low-back complaints was 11.3%.

Table 3 shows a comparison between the multivariate adjusted odds ratios obtained from the cross-sectional baseline study and the follow-up study.

Low physical and low psychosocial exposure was used as the reference group. The relationship between different combinations of exposure to physical and psychosocial work risk factors was similar in both the baseline and follow-up study. The likelihood of reporting new episodes of recurrent low-back problems was greatest (OR 4) for workers highly exposed to both physical and psychosocial work risk factors compared to the reference group. There was approximately a twofold increase in the likelihood for workers highly exposed to physical work risk factors and not highly exposed to psychosocial work risk factors. The group with low physical exposure and high psychosocial exposure had a lower odds ratio than the two groups with high physical exposure.

Table 3 Comparing the likelihood of self-reported low-back complaints for all subjects at baseline (N=2608) and for the cohort at follow-up (N=1021) who did not report low-back complaints at baseline for all variables in the mixed domain model

	Baseline study		***Follow-up study***	
	aOR	***(95% CI***	***aOR***	***(95% CI)***
Low physical-low psychosocial exposure	1.00	-	1.00	-
Low physical-high psychosocial exposure	1.66	1.36-2.01	1.43	0.92-2.21
High physical-low psychosocial exposure	2.21	1.48-3.31	1.77	0.64-4.89
High physical-high psychosocial exposure	3.75	2.75-5.11	4.00	1.88-8.50
Age	1.25	1.05-1.49	1.26	0.84-1.89
Gender	1.16	0.96-1.41	1.08	0.70-1.66
Hours worked per week	1.01	0.83-1.23	0.91	0.57-1.44
Shift-work	1.08	0.88-1.32	1.06	0.66-1.70
Job satisfaction	1.32	1.02-1.70	1.56	0.87-2.80
Reducing stress depends on how much a person stays away from a situation that makes the problem worse	1.15	0.96-1.38	0.81	0.53-1.24

Similar adjusted odds ratios were obtained in the baseline cross-sectional study and the follow-up study for age, gender, hours worked per week, shift-work, job satisfaction and the lay belief about the alleviation of stress.

Table 4 shows the univariate odds ratio (sOR) for perceived job stress, perceived life stress, mental strain, psychosomatic symptoms and depression. Perceived life stress and perceived job stress increased the likelihood of reporting new episodes of self-reported low-back complaints. Psychosomatic symptoms, mental strain or depression also increased the likelihood but it was unclear whether these were true effects.

Each factor in table 4 was entered into a regression model with each physical/psychosocial exposure variable, age and gender. None of the adjusted odds ratios indicated an independent effect upon the likelihood of developing new episodes of self-reported low-back complaints.

Table 4 Comparing the likelihood of new episodes of self-reported low-back complaints for subjects who did not report complaints at baseline for individual reactivity measures adjusted for age, gender and physical and psychosocial exposure combinations (N= 983)

	Follow-up study			
	sOR	***(95% CI)***	***aOR***	***(95% CI)***
Perceived job stress	1.74	0.97-3.10	1.38	0.71-2.71
Perceived life stress	1.55	1.04-2.31	1.49	0.91-2.45
Mental strain	1.31	0.81-2.13	1.06	0.61-1.85
Psychosomatic symptoms	1.42	0.93-2.17	1.24	0.78-1.98
Depression	1.16	0.78-1.73	0.85	0.52-1.39

Table 5 Results from multivariate analyses for the relationship between physical and psychosocial work risk factors and new episodes of self-reported low-back complaints with inclusion of potential intermediate individual reactions

Exposure factor	***Model I*** [a]	***Model II*** [b]	***Model III*** [c]
Low physical-low psychosocial	1.00	1.00	1.00
Low physical-high psychosocial	1.16 (0.67-2.01)	0.93 (0.51-1.71)	1.18 (0.75-1.88)
High physical-low psychosocial	2.14 (0.99-4.62)	2.28 (1.05-4.96)	1.54 (0.57-4.16)
High physical-high psychosocial	3.96 (1.67-9.40)	2.93 (1.17-7.33)	2.83 (1.30-6.18)

a Adjusted odds ratios and 95% CI for age and gender
b Adjusted odds ratios and 95% CI for age, gender, perceived job stress and perceived life stress
c Adjusted odds ratios and 95% CI for age, gender, perceived job stress, perceived life stress and psychosomatic symptoms

Referring to table 5, perceived job stress and perceived life stress were then entered into a model with each physical/psychosocial exposure combination, age and gender (model II). The

adjusted odds ratios for this model were compared to the model with only the physical/psychosocial exposure combinations, age and gender (model I). Psychosomatic symptoms was entered into a model containing the factors in model II to observe changes in the adjusted odds ratios (model III).

Workers highly exposed to both physical and psychosocial work risk factors also had a tendency to report perceived job stress. After adjustment for both perceived job stress and perceived life stress in model II, the adjusted odds ratio for the group highly exposed to physical and psychosocial work risk factors reduced markedly. This indicated that perceived job stress and perceived stress in life played an intermediate role between high exposure to physical and psychosocial workplace risk factors and the development of new episodes of self-reported low-back complaints. Further adjustment in model III for psychosomatic symptoms had a marked reduction effect on the adjusted odds ratio for the high physical-low psychosocial exposure group. This indicated that psychosomatic symptoms played an intermediate role between high exposure to physical workplace risk factors and low exposure to psychosocial workplace risk factors and the outcome.

4.3 CONCLUSIONS ON SELF-REPORTED LOW-BACK COMPLAINTS

The stage I analyses showed that extrinsic effort, intrinsic effort, role conflict and a threat of physical harm or injury were psychosocial workplace factors associated with self-reported low-back complaints. Frequent or heavy lifting in awkward posture and manual handling involving lifting were physical workplace factors associated with self-reported low-back complaints. Workers highly exposed to combinations of both physical and psychosocial work risk factors had the greatest likelihood of reporting low-back complaints. A potential interaction between physical and psychosocial workplace risk factors was observed. Lay beliefs about stress were not associated with self-reported low-back complaints.

The prospective data analysis in stage II confirmed the relationship observed in the baseline data analysis of stage I. High exposure to both physical and psychosocial workplace risk factors predicted new episodes of self-reported low-back complaints. High exposure to psychosocial factors alone was insufficient to increase the likelihood. High exposure to physical workplace risk factors was necessary for psychosocial factors to have an effect on the likelihood.

Low job satisfaction was associated with reporting low-back complaints. This factor may also predict new episodes of low-back complaints but a true effect was not observed. Age, gender, hours worked per week, shift-work or lay beliefs about stress did not predict new episodes of self-reported low-back complaints.

The importance of individual reactivity was assessed in the development of new episodes of self-reported low-back complaints. Perceived job stress and perceived life stress were likely to play an intermediate role in the relationship between high exposure to physical and psychosocial workplace risk factors and the outcome.

5 SELF-REPORTED UPPER BACK COMPLAINTS

Factors within the work organisation domain, the psychosocial work domain, individual domain (demographic, trait and attitude), the physical work domain and individual reactivity have all been implicated in the development of self-reported musculoskeletal complaints.

The analyses in this section are split into two stages. The stage I analyses were conducted to investigate whether organisational, physical, psychosocial or individual factors were associated with reporting self-reported upper back complaints in the baseline cross-sectional study. The stage II analyses were conducted to investigate whether the factors associated with self-reported upper back complaints in stage I also increased the likelihood of reporting this outcome in the follow-up study of workers who did not report these complaints in the baseline cross-sectional study. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

The factors associated with the reporting of upper back complaints that also preceded and increased the likelihood of reporting new episodes would satisfy the criteria of association and time order indicating involvement in the causation of this outcome.

Of the 3139 subjects responding to the baseline study questionnaire, 2990 reported a rating on self-reported upper back complaints. Self-reported upper back complaints were defined as having problems more than three times or lasting more than one week in the previous year in the area between the shoulder blades. About 8% reported such a problem, of which approximately:-

- 61% reported separate episodes of upper back problems in the last year with a frequency of at least once a month.
- 33% reported that symptoms lasted between one day and one week, 18.1 % experienced episodes of upper back problems which lasted more than one week.
- 49 % experienced an upper back problem in the last seven days.
- 73 % reported that symptoms were not present when they first started the present job.
- 26% rated their pain right now between three and five on a pain scale with a score of five indicating intolerable pain and a score of one indicating no pain.
- 17% had missed work in the last year for at least one day due to the problem.

The outcome measure for self-reported upper back complaints also included workers who experienced chronic and acute upper back problems who required work absence.

5.1 STAGE I ANALYSES FOR SELF-REPORTED UPPER BACK COMPLAINTS

This section describes the results of the domain specific regression models and the factors selected for inclusion into the mixed domain model.

Referring to the crude odds ratios in table 1 in appendix 3, high job demands, low decision latitude, low social support, high extrinsic effort, high intrinsic effort, low reward, high role conflict, high role ambiguity, frequent verbal abuse and the frequent threat of harm/injury were psychosocial work factors univariately associated with self-reported upper back complaints. A tentative increase in the likelihood was observed for high job future ambiguity and so was excluded from subsequent analyses. The exclusion of cases with missing data had little effect on the association between each psychosocial work risk factor and the outcome.

After adjustment for the effects of each factor upon the other (refer to the adjusted odds ratios in table 1 in appendix 3), high exposure to role ambiguity, role conflict and threat of harm/injury was associated with self-reported upper back complaints. These variables were included in the mixed domain model.

A tentative increase in the likelihood was observed for decision latitude, extrinsic effort, intrinsic effort, social support, reward, and verbal abuse. Job demands was unlikely to be a risk factor. All these factors were excluded in the final model. A considerable reduction was observed between the univariate and multivariate odds ratios for each factor. This suggested inter-relationships between the psychosocial work factors.

The number of hours normally worked per week, working a late or night shift, the type of hours worked or travel time to work were not associated with self-reported upper back complaints. These factors were not included in subsequent analysis.

Referring to table 2 in appendix 3, physical work factors univariately associated with self-reported upper back complaints were:-

- lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position
- working with the elbows normally at or above shoulder height
- working with the head/neck bent or twisted excessively
- repetitive wrist movements for much of the normal working day.

The exclusion of cases with missing data for these factors had little effect on the odds ratios. After adjustment for the effects of each factor upon the other, working with the elbows normally at or above shoulder height was tentatively associated with the outcome. The other three factors showed a strong association (OR 1.5) and were included in the mixed domain model.

Referring to table 3 in appendix 3, gender (an individual demographic factor), high scores on neuroticism, rumination, positive and negative effect (individual trait factors), life and job satisfaction (individual well-being factors) were univariately associated with self-reported upper back complaints. Being satisfied with your life and having a positive mood reduced the likelihood. Not being satisfied with your job increased the likelihood of self-reported upper back complaints. Age did not have a univariate association with the outcome but remained in subsequent analyses as a potential confounder.

The lay beliefs about causes and alleviation of stress univariately associated with self-reported upper back complaints were:-

- the person is stressed at work usually because he/she has no friends

- stress mainly affects people who have an unsympathetic boss
- if an organisation has a lot of young employees, older ones tend to feel threatened by this, which leads to stress
- reducing stress depends on how embarrassed the person feels about having the problem.

The exclusion of cases with missing data had little effect on the odds ratios. After adjustment for the effects of each factor (demographics, traits, attitudes and well-being factors) upon the other, only gender, neuroticism, low job satisfaction and the belief that reducing stress depends on how embarrassed the person feels about having a problem were associated with self-reported upper back complaints. These factors were included in the mixed domain model.

The psychosocial work risk factors that remained significant in the domain-specific multivariate model (role ambiguity, role conflict and threat of harm/injury) were used to create a psychosocial exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 or more factors).

The physical work risk factors that remained significant in the domain-specific multivariate model (lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position, working with the head/neck bent or twisted excessively and repetitive wrist movements for much of the normal working day) were used to create a physical exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 factors).

The physical and psychosocial exposure variables were used to create four indicator variables for different combinations of exposure to physical and psychosocial work risk factors and are shown in the mixed domain model in table 6.

The mixed domain model shown in table 6 identifies the smallest number of factors associated with self-reported upper back complaints.

Workers highly exposed to psychosocial work risk factors and not physical work risk factors were 1.7 times more likely to report self-reported upper back complaints compared to workers with low exposure to both of these factors.

Workers highly exposed to physical work risk factors and not to psychosocial work risk factors were approximately 2 times more likely to report problems compared to workers without high exposure to either physical or psychosocial work risk factors.

The greatest likelihood of reporting self-reported upper back complaints was for workers highly exposed to both physical and psychosocial work risk factors. They were 2.7 times more likely to report problems compared to workers with neither set of factors. The confidence interval for the adjusted odds ratios for each exposure group suggested a true effect.

An epidemiological interaction effect was not observed (AP=0.03 95%CI –0.51-0.57) between physical and psychosocial work risk factors indicated by a departure from an additive model of risk.

The only individual factors significantly associated with self-reported upper back complaints were gender, neuroticism and low job satisfaction. Age was an unlikely true effect and the lay belief about the alleviation of stress was tentatively associated with the outcome.

In summary, physical and psychosocial workplace factors and individual factors were strongly associated with workers reporting self-reported upper back complaints. The combined effects of high exposure to physical and psychosocial work risk factors increased the likelihood of reporting the outcome. An interaction effect between physical and psychosocial workplace risk factors was not observed.

5.2 STAGE II ANALYSES FOR SELF-REPORTED UPPER BACK COMPLAINTS

The stage I analyses showed the factors associated with self-reported upper back complaints. The stage II analyses in this section were conducted in order to determine whether the factors associated with complaints in the stage I analyses also predicted new episodes of self-reported upper back complaints. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

In the baseline cross-sectional study, workers who did not report having upper back complaints in the last 12 months were selected for the follow-up cohort (2685 workers). In total, 1937 (72%) responded to the follow-up questionnaire and were included in the prospective data analysis. The cumulative incidence of self-reported upper back complaints was 8.9%.

Table 6 shows a comparison between the multivariate adjusted odds ratios obtained from the cross-sectional baseline study and the follow-up study.

Table 6 Comparing the likelihood of self-reported upper back complaints for all subjects at baseline (N=2572) and for the cohort at follow-up, who did not report self-reported upper back complaints at baseline for all variables in the mixed domain model (N=1573)

	Baseline study		***Follow-up study***	
	aOR	***(95% CI)***	***aOR***	***(95% CI)***
Low physical-low psychosocial exposure	1.00	-	1.00	-
Low physical-high psychosocial exposure	1.69	1.20-2.39	1.14	0.74-1.76
High physical-low psychosocial exposure	1.89	1.12-3.20	1.59	0.81-3.12
High physical-high psychosocial exposure	2.67	1.69-4.24	1.63	0.62-1.27
Age	0.88	0.66-1.18	0.88	0.62-1.27
Gender	1.57	1.17-2.12	1.43	0.99-2.07
Neuroticism	1.38	1.00-1.90	1.32	0.90-1.92
Life satisfaction	0.83	0.61-1.13	0.76	0.52-1.10
Job satisfaction	1.53	1.04-2.25	1.21	0.71-2.07
Reducing stress depends on how embarrassed the person feels about having the problem	1.27	0.95-1.71	1.10	0.77-1.58

Low physical and low psychosocial exposure was used as the reference group. The likelihood

of reporting new episodes of self-reported upper back complaints was greatest (OR 1.63) for workers highly exposed to both physical and psychosocial work risk factors. There was a similar increase in the likelihood for workers highly exposed to physical work risk factors and not highly exposed to psychosocial work risk factors. The group with low physical exposure but high psychosocial exposure had a lower odds ratio than the two groups with high physical exposure. None of the exposure factors showed a true effect.

Similar adjusted odds ratios were obtained in the baseline cross-sectional study and the follow-up study for age, gender, neuroticism, life satisfaction, job satisfaction and the lay belief about the alleviation of stress.

Table 7 shows the univariate odds ratio (sOR) for perceived job stress, perceived life stress, mental strain, psychosomatic symptoms and depression. Univariate odds ratios (sOR) indicated that perceived job stress, perceived life stress, psychosomatic symptoms and depression increased the likelihood of reporting new episodes of self-reported upper back complaints. The data also suggested that mental strain increased the likelihood, but it was unclear whether this was a true effect.

Each factor in table 7 was entered into a regression model with each physical/psychosocial exposure variable, age and gender. The adjusted odds ratios for psychosomatic symptoms and depression indicated an independent effect upon the likelihood of developing self-reported upper back complaints. However, there was a marked reduction in the adjusted odds ratios for all factors indicating strong interrelationships.

Table 7 Comparing the likelihood of new episodes of self-reported upper back complaints for subjects who did not report upper back complaints at baseline by individual reactivity measures adjusted for age, gender, physical and psychosocial exposure combinations (N= 1392)

	Follow-up study			
	sOR	***(95% CI)***	***aOR***	***(95% CI)***
Perceived job stress	1.90	1.21-3.01	1.41	0.85-2.32
Perceived life stress	1.73	1.21-2.46	1.10	0.71-1.70
Mental strain	1.34	0.88-2.03	0.77	0.48-1.24
Psychosomatic symptoms	2.49	1.76-3.53	1.91	1.30-2.80
Depression	2.16	1.51-3.09	1.66	1.07-2.59

Table 8 Results from multivariate analyses for the relationship between physical and psychosocial work risk factors and new episodes of self-reported upper back complaints with inclusion of potential intermediate individual reactions

Exposure factor	*Model I* [a]	*Model II* [b]	*Model III* [c]
Low physical-low psychosocial	1.00	1.00	1.00
Low physical-high psychosocial	1.21 (0.79-1.84)	1.04 (0.67-1.61)	0.92 (0.59-1.43)
High physical-low psychosocial	1.87 (1.00-3.52)	1.86 (0.99-3.51)	1.62 (0.85-3.09)
High physical-high psychosocial	1.76 (0.94-3.30)	1.50 (0.79-2.84)	1.25 (0.65-2.38)

a Adjusted odds ratios and 95% CI for age and gender
b Adjusted odds ratios and 95% CI for age, gender, perceived job stress and perceived life stress
c Adjusted odds ratios and 95% CI for age, gender, perceived job stress, perceived life stress, depression and psychosomatic symptoms

Referring to table 8, perceived job stress and perceived life stress were entered into a model with each physical/psychosocial exposure combination, age and gender (model II). The adjusted odds ratios for this model were compared to the model with only the physical/psychosocial exposure combinations, age and gender (model I). Depression and psychosomatic symptoms was entered into a model containing the factors in model II to observe changes in the adjusted odds ratios (model III).

After adjustment for both perceived stress factors in model II, the adjusted odds ratio for the exposure groups with high psychosocial work risk factors reduced markedly. This indicated that perceived job stress and perceived stress in life played an intermediate role between exposure to psychosocial workplace risk factors and the development of new episodes of self-reported upper back complaints. Further adjustment in model III for depression and psychosomatic symptoms appeared to have little effect on the adjusted odds ratios for each of the physical/psychosocial exposure groups. Depression and psychosomatic symptoms showed independent effects on the outcome.

5.3 CONCLUSIONS ON SELF-REPORTED UPPER BACK COMPLAINTS

The stage I analyses showed that role ambiguity, role conflict and threat of harm/injury were psychosocial workplace factors associated with self-reported upper back complaints. Frequent or heavy lifting in awkward posture, working with the head/neck bent or twisted excessively and repetitive wrist movements for much of the normal working day were physical workplace factors associated with self-reported upper back complaints. Workers highly exposed to combinations of both physical and psychosocial work risk factors had the greatest likelihood of reporting these complaints. An interaction effect between physical and psychosocial workplace risk factors was not observed. Gender, neuroticism and low job satisfaction was associated with self-reported upper back complaints. Lay beliefs about stress were not associated with the outcome.

The prospective data analysis in stage II did not confirm the relationship observed in the baseline data analysis of stage I. High exposure to physical and psychosocial work risk factors resulted in a adjusted odds ratio similar to the group with high exposure physical and low

exposure psychosocial work risk factors.

Gender and neuroticism were associated with reporting upper back complaints. Theses factors may also predict new episodes of upper back complaints but a true effect was not observed. Age, life satisfaction, job satisfaction and lay beliefs about stress did not predict new episodes of self-reported upper back complaints.

The importance of individual reactivity was assessed in the development of new episodes of self-reported upper back complaints. Psychosomatic symptoms and depression were strong predictors of new episodes of self-reported upper back complaints and had independent effects upon the outcome. Perceived job stress and perceived life stress were likely to play an intermediate role in the relationship between high exposure to psychosocial work risk factors and self-reported upper back complaints but the effect appeared to be small.

6 SELF-REPORTED NECK COMPLAINTS

Factors within the work organisation domain, the psychosocial work domain, individual domain (demographic, trait and attitude), the physical work domain and individual reactivity have all been implicated in the development of self-reported musculoskeletal complaints.

The analyses in this section are split into two stages. The stage I analyses were conducted to investigate whether organisational, physical, psychosocial or individual factors were associated with reporting self-reported neck complaints in the baseline cross-sectional study. The stage II analyses were conducted to investigate whether the factors associated with self-reported neck complaints in stage I also increased the likelihood of reporting this outcome in the follow-up study of workers who did not report neck complaints in the baseline cross-sectional study. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

The factors associated with the reporting of neck complaints that also preceded and increased the likelihood of reporting new episodes would satisfy the criteria of association and time order indicating involvement in the causation of this outcome.

Of the 3139 subjects responding to the baseline study questionnaire, 2955 reported a rating on self-reported neck complaints, defined as having problems more than three times or lasting more than one week in the previous year. About 18% reported such a problem, of which approximately:-

- 61% reported separate episodes of the neck problems in the last year with a frequency of at least once a month.
- 37% reported that symptoms lasted between one day and one week, 19% experienced episodes of neck pain that lasted more than 1 week.
- 54% experienced a neck problem in the last seven days.
- 70% reported that symptoms were not present when they first started the present job.
- 28% rated their pain right now between three and five, on a pain scale with a score of five indicating intolerable pain and a score of one indicating no pain.
- 20% reported that the neck problems started after a sudden injury to the neck such as whiplash or fracture.
- 17% had missed work in the last year for at least one day due to the problem.
- 20% had to perform light or restricted work in the last year because of their low neck problem.
- 69% reported that specific activities at work made the problem worse.

The outcome measure for self-reported neck complaints also included workers who experienced chronic and acute neck problems and required work absence.

6.1 STAGE I ANALYSES FOR SELF-REPORTED NECK COMPLAINTS

This section describes the results of the domain specific regression models and the factors selected for inclusion into the mixed domain model.

Referring to table 1 in appendix 4, high job demands, low social support, high extrinsic effort, high intrinsic effort, low reward, high role ambiguity, high role conflict frequent verbal abuse and the frequent threat of harm/injury were psychosocial work factors univariately associated with self-reported neck complaints. A tentative increase in the likelihood was observed for low decision latitude and so was excluded from subsequent analyses. The exclusion of cases with missing data had little effect on the association between each psychosocial work risk factor and the outcome.

After adjustment for the effects of each factor upon the other (refer to the adjusted odds ratios in table 1 in appendix 4), high exposure to intrinsic effort, job future ambiguity and verbal abuse and/or confrontations with clients or the general public was associated with self-reported neck complaints. These variables were included in the mixed domain model.

A tentative increase in the likelihood was observed for job demands, social support, reward, role ambiguity, role conflict and threat of harm for/injury. Extrinsic effort was unlikely to be a risk factor, as indicated by the odds ratio and confidence interval. All these factors were excluded in the mixed domain model. A considerable reduction was observed between the univariate and multivariate odds ratios for each factor. This suggested inter-relationships between the psychosocial work factors.

Referring to table 2 in appendix 4, the number of hours normally worked per week, working a late or night shift, the type of hours worked or travel time to work were not associated with self-reported neck complaints. These factors were not included in subsequent analysis.

Referring to table 3 in appendix 4, physical work factors univariately associated with self-reported neck complaints were:-

- lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position
- repetitive arm movements
- working with the head/neck bent or twisted excessively
- vibration from a power tool or machine that made the vibrate break during the past week
- sitting and using a computer more than half the time
- seated for 30 minutes or more without a break whilst carrying out work.

The exclusion of cases with missing data for these factors had little effect on the odds ratios. After adjustment for the effects of each factor upon the other, the factor for repetitive arm movements was tentatively associated with the outcome. The other five factors showed a strong association (OR> 1.5) and were included in the mixed domain model.

Referring to table 4 in appendix 4, gender (an individual demographic factor), high scores on neuroticism, rumination, positive and negative effect (individual trait factors), life and job satisfaction (individual well-being factors) were univariately associated with self-reported neck complaints. Being satisfied with your life and having a positive mood reduced the likelihood. Not being satisfied with your job increase the likelihood of self-reported neck complaints. Age had a tentative univariate association with the outcome but remained in subsequent analyses as a potential confounder.

Referring to table 5 in appendix 4, the lay beliefs about causes and alleviation of stress univariately associated with self-reported neck complaints were:-

- if an organisation has a lot of young employees, older ones tend to feel threatened by this, which leads stress
- women are more stressed than men at work because their careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotions
- it is less stressful to be checked upon regularly at work, because this avoids possible mistakes and it is helpful in pointing out expectations
- reducing stress depends on whether the person joins other self-help groups for their problems.

The exclusion of cases with missing data had little effect on the odds ratios. Age, gender, negative effect and low job satisfaction, and the following beliefs were associated with self-reported neck complaints in the adjusted analysis:-

- if an organisation has a lot of young employees, older ones tend to feel threatened by this, which leads stress
- it is less stressful to be checked upon regularly at work, because this avoids possible mistakes and it is helpful in pointing out expectations
- reducing stress depends on whether the person joins other self-help groups for their problems

These factors were included in the mixed domain model.

The psychosocial work risk factors that remained significant in the domain-specific multivariate model (intrinsic effort, job future ambiguity and verbal abuse and/or confrontations with clients or the general public) were used to create a psychosocial exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 or more factors).

The physical work risk factors that remained significant in the domain-specific multivariate model (lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position, working with the head/neck bent or twisted excessively, vibration from a power tool or machine that made the hands vibrate during the past week, sitting and using a computer more than half the time, seated for 30 minutes or more without a break whilst carrying out work) were used to create a physical exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 factors).

The physical and psychosocial exposure variables were used to create four indicator variables for different combinations of exposure to physical and psychosocial work risk factors and are shown in the mixed domain model in table 9.

The mixed domain model shown in table 9 identifies the smallest number of factors associated with self-reported neck complaints.

Workers highly exposed to psychosocial work risk factors and not physical work risk factors were 1.7 times more likely to report self-reported neck complaints compared to workers with low exposure to both of these factors.

Workers highly exposed to physical work risk factors and not to psychosocial work risk factors were approximately 2 times more likely to report complaints compared to workers without high exposure to either physical or psychosocial work risk factors.

The greatest likelihood of reporting self-reported neck complaints was for workers highly exposed to both physical and psychosocial work risk factors. They were 3 times more likely to report complaints compared to workers with neither set of factors. The confidence interval for the adjusted odds ratios for each exposure group suggested a true effect.

A tentative epidemiological interaction effect (AP=0.18 95%CI –0.17-0.41) was observed between physical and psychosocial work risk factors indicated by a departure from an additive model of risk.

The individual factors significantly associated with self-reported neck complaints were age, gender(female), negative mood and low job satisfaction and the 3 lay belief factors entered in the mixed domain model.

Summarising the results of the stage I analysis, physical and psychosocial workplace factors and individual factors (gender, traits, attitudes and well-being) were associated with workers reporting self-reported neck complaints. The combined effects of high exposure to physical and psychosocial work risk factors increased the likelihood of reporting the outcome.

6.2 STAGE II ANALYSES FOR SELF-REPORTED NECK COMPLAINTS

The stage I analyses showed the factors associated with self-reported neck complaints. The stage II analyses in this section were conducted in order to determine whether the factors associated with self-reported neck complaints in the stage I analyses also predicted new episodes of the outcome. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

At baseline, workers who did not report having neck problems in the last 12 months were selected for the follow-up cohort (2223 workers). In total 1601 (72%) responded to the follow-up questionnaire and were included in the prospective data analysis. The cumulative incidence of self-reported neck complaints was 12%.

Table 9 shows a comparison between the multivariate adjusted odds ratios obtained from the cross-sectional baseline study and the follow-up study.

Table 9 Comparing the likelihood of self-reported neck complaints for all subjects at baseline (N=2513) and for the cohort at follow-up, who did not report self-reported neck complaints at baseline for all factors in the mixed domain model (N=1323)

	Baseline study		***Follow-up study***	
	aOR	***(95% CI)***	***aOR***	***(95% CI)***
Low physical-low psychosocial exposure	1.00	-	1.00	-
Low physical-high psychosocial exposure	1.65	1.08-2.52	0.68	0.32-1.45
High physical-low psychosocial exposure	1.94	1.44-2.61	1.11	0.72-1.70
High physical-high psychosocial exposure	2.93	2.11-4.08	1.98	1.22-3.22
Age	1.35	1.09-1.66	1.03	0.72-1.46
Gender	1.64	1.33-2.03	0.91	0.63-1.33
Negative mood	1.31	1.05-1.63	1.36	0.96-1.95
Job satisfaction	1.74	1.30-2.33	1.06	0.60-1.87
If an organisation has a lot of young employees, older ones tend to feel threatened by this, which leads stress	1.24	0.99-1.55	0.87	0.59-1.29
Reducing stress depends on whether the person joins other self-help groups for their problems	0.79	0.62-1.03	1.12	0.76-1.65
It is less stressful to be checked upon regularly at work, because this avoids possible mistakes and it is helpful in pointing out expectations	0.71	0.55-0.91	1.36	0.94-1.95

Low physical and low psychosocial exposure was used as the reference group. The likelihood of reporting new episodes of self-reported neck complaints was greatest (OR 1.98) for workers highly exposed to both physical and psychosocial work risk factors compared to the reference

group. There was a lesser increase in the likelihood for workers highly exposed to physical work risk factors and not highly exposed to psychosocial work risk factors. The group with low physical exposure but high psychosocial exposure had a lower odds ratio than the two groups with high physical exposure. An interaction effect between high exposure to physical and psychosocial work risk factors was observed in the follow-up study.

Age, gender, negative mood, low job satisfaction and the beliefs about stress did not predict the onset of new episodes of self-reported neck complaints.

Table 10 shows the univariate odds ratio (sOR) for perceived job stress, perceived life stress, mental strain, psychosomatic symptoms and depression. Univariate odds ratios (sOR) indicated that perceived life stress, psychosomatic symptoms, mental strain, and depression increased the likelihood of reporting new episodes of self-reported neck complaints. The data also suggested that perceived job stress did not increase the likelihood.

Each factor in table 10 was entered into a regression model with each physical/psychosocial exposure variable, age and gender. The adjusted odds ratios for depression indicated an independent effect upon the likelihood of developing self-reported neck complaints. However, there was a marked reduction in the adjusted odds ratios for all factors indicating interrelationships.

Table 10 Comparing the likelihood of new episodes of self-reported neck complaints for subjects who did not report neck complaints at baseline by individual reactivity measures, adjusted for age, gender, physical and psychosocial exposure combinations (N= 1288)

	Follow-up study			
	sOR	***(95% CI)***	***aOR***	***(95% CI)***
Perceived job stress	1.10	0.63-1.92	0.68	0.37-1.25
Perceived life stress	1.44	1.02-2.03	0.96	0.62-1.48
Mental strain	1.86	1.26-2.73	1.37	0.86-2.18
Psychosomatic symptoms	1.58	1.10-2.26	1.23	0.82-1.83
Depression	1.83	1.29-2.59	1.59	1.03-2.46

Table 11 Results from multivariate analyses for the relationship between physical and psychosocial work risk factors and new episodes of self-reported neck complaints with inclusion of potential intermediate individual reactions

Exposure factor	*Model I* [a]	*Model II* [b]	*Model III* [c]
Low physical-low psychosocial	1.00	1.00	1.00
Low physical-high psychosocial	0.78 (0.37-1.67)	0.73 (0.34-1.58)	0.70 (0.32-1.51)
High physical-low psychosocial	1.15 (0.75-1.78)	1.16 (2.75-1.79)	1.23 (0.79-1.90)
High physical-high psychosocial	2.34 (1.45-3.78)	2.22 (1.35-3.66)	2.19 (1.33-3.61)

a Adjusted odds ratios and 95% CI for age and gender
b Adjusted odds ratios and 95% CI for age, gender, perceived job stress and perceived life stress
c Adjusted odds ratios and 95% CI for age, gender, perceived job stress, perceived life stress, depression

Referring to table 11, perceived job stress and perceived life stress were entered into a model with each physical/psychosocial exposure combination, age and gender (model II). The adjusted odds ratios for this model were compared to the model with only the physical/psychosocial exposure combinations, age and gender (model I). Depression was entered into a model containing the factors in model II to observe changes in the adjusted odds ratios (model III).

The modelling revealed that there was unlikely to be an intermediate effect for perceived job stress. Adjusting for depression did not markedly effect the adjusted odds ratios for each exposure group.

6.3 CONCLUSIONS ON SELF-REPORTED NECK COMPLAINTS

The stage I analyses showed intrinsic effort, job future ambiguity and verbal abuse and/or confrontations with clients or the general public were psychosocial workplace factors associated with self-reported neck complaints. Frequent or heavy lifting in awkward posture, working with the head/neck bent or twisted excessively, vibration from a power tool or machine that made the vibrate break during the past week, sitting and using a computer more than half the time and seated for 30 minutes or more without a break whilst carrying out work were physical workplace factors associated with self-reported neck complaints. Workers highly exposed to both physical and psychosocial work risk factors had the greatest likelihood of reporting this outcome. The interaction effect observed between high exposure to physical and psychosocial workplace risk factors was unlikely to be a true effect. Age, gender, negative mood, low job satisfaction were associated with self-reported neck complaints. The belief that being check upon regularly is less stressful significantly reduced the likelihood of reporting high perceived job stress.

The prospective data analysis in stage II showed that high exposure to physical and psychosocial work risk factors resulted in a two-fold increase in the likelihood of reporting new episodes of self-reported neck complaints.

None of the individual factors associated with the outcome in the stage I analyses increased the likelihood of new episodes of self-reported neck complaints being reported. In addition, none of the lay beliefs in the mixed domain model increased the likelihood either.

The importance of individual reactivity was assessed in the development of new episodes of self-reported neck complaints. Depression was the only strong predictor of new episodes of self-reported neck complaints and had an independent effect upon the outcome. Perceived job stress and perceived life stress did not have a marked intermediate role in the relationship between high exposure to both or either physical and psychosocial work risk factors and self-reported neck complaints.

7 SELF-REPORTED SHOULDER COMPLAINTS

Factors within the work organisation domain, the psychosocial work domain, individual domain, the physical work domain and individual reactivity have all been implicated in the development of self-reported musculoskeletal complaints.

The analyses in this section are split into two stages. The stage I analyses were conducted to investigate whether organisational, physical, psychosocial or individual factors were associated with reporting self-reported shoulder complaints in the baseline cross-sectional study. The stage II analyses were conducted to investigate whether the factors associated with self-reported shoulder complaints in stage I also increased the likelihood of reporting this outcome in the follow-up study of workers who did not report complaints in the baseline cross-sectional study. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

The factors associated with the reporting of shoulder complaints that also preceded and increased the likelihood of reporting new episodes would satisfy the criteria of association and time order indicating involvement in the causation of this outcome.

Of the 3139 subjects responding to the baseline study questionnaire, 2995 reported a rating on self-reported shoulder complaints, defined as having problems more than three times or lasting more than one week in the previous year. About 17% reported such a problem of which approximately:-

- 61 % reported separate episodes of the shoulder problems in the last year with a frequency of at least once a month.
- 30% reported that symptoms lasted between one day and one week, 32% experienced episodes of shoulder pain which lasted more than one week.
- 55% experienced a shoulder problem in the last seven days.
- 73% reported that symptoms were not present when they first started the present job.
- 35% rated their pain right now between three and five on a pain scale with a score of five indicating intolerable pain and a score of one indicating no pain.
- 19% had missed work in the last year for at least one day due to the problem.

The outcome measure for self-reported shoulder complaints in this study also included workers who experienced experienced chronic and acute shoulder problems who required work absence.

7.1 STAGE I ANALYSES FOR SELF-REPORTED SHOULDER COMPLAINTS

This section describes the results of the domain specific regression models and the factors selected for inclusion into the mixed domain model.

Referring to table 1 in appendix 5, high job demands, low decision latitude, low social support, high extrinsic effort, high intrinsic effort, low reward, high role ambiguity, high role conflict, job future ambiguity, frequent verbal abuse and the frequent threat of harm/injury were psychosocial work factors univariately associated with self-reported shoulder complaints. The exclusion of cases with missing data had little effect on the association between each psychosocial work risk factor and the outcome.

After adjustment for the effects of each factor upon the other, high exposure to low social support, low reward, job future ambiguity and threat of harm/injury was associated with self-reported shoulder complaints. These variables were included in the mixed domain model.

A tentative increase in the likelihood was observed for job demands, extrinsic effort, intrinsic effort, verbal abuse. Role ambiguity, role conflict and decision latitude were unlikely to be risk factor. All these factors were excluded in the mixed domain model. A considerable reduction was observed between the univariate and multivariate odds ratios for each factor. This suggested inter-relationships between the psychosocial work factors.

The number of hours normally worked per week, working a late or night shift, the type of hours worked or travel time to work were not associated with self-reported shoulder complaints. These factors were not included in subsequent analyses.

Referring to table 2 in appendix 5, physical work factors univariately associated with self-reported shoulder complaints were:-

- working with the elbows normally at or above shoulder height
- working with the head/neck bent or twisted excessively
- lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position
- repetitive wrist movements for much of the normal working day
- repetitive arm movements
- seated for 30 minutes or more without a break
- working with a deviated or bent wrist position.

The exclusion of cases with missing data for these factors had little effect on the odds ratios. After adjustment for the effects of each factor upon the other, working with a deviated or bent wrist position and working with the elbows normally at or above shoulder height were not likely to be independent factors. The other five factors showed an association with the outcome and were included in the mixed domain model.

Referring to table 3 in appendix 5, age, gender (individual demographic factors), high scores on neuroticism, rumination, negative effect (individual trait factors) and job satisfaction (individual well-being factors) were univariately associated with self-reported shoulder complaints. Being satisfied with your life and having a positive mood reduced the likelihood. Not being satisfied with your job increased the likelihood of self-reported shoulder complaints.

Referring to table 4 in appendix 5, the lay beliefs about causes and alleviation of stress univariately associated with self-reported shoulder complaints were:-

- women are more stressed than men at work because their careers develop more slowly, and they are expected to perform better their male colleagues to obtain promotions
- a woman will be more stressed at work because male attitudes towards female bosses all colleagues create a difficult and constantly challenging climate
- people whose work involves physical danger, like policeman, are often very stressed
- reducing stress depends on how much self-control the person has.

The exclusion of cases with missing data had little effect on the odds ratios. Age, gender, negative mood and low job satisfaction were associated with self-reported shoulder complaints in the adjusted analyses. These factors were included in the mixed domain model.

The psychosocial work risk factors that remained significant in the domain-specific multivariate model (low social support, low reward, job future ambiguity and threat of harm/injury) were used to create a psychosocial exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 or more factors).

The physical work risk factors that remained significant in the domain-specific multivariate model (working with the head/neck bent or twisted excessively, lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position, repetitive wrist movements for much of the normal working day, repetitive arm movements, seated for 30 minutes or more without a break) were used to create a physical exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 factors).

The physical and psychosocial exposure variables were used to create four indicator variables for different combinations of exposure to physical and psychosocial work risk factors and are shown in the mixed domain model in table 12. It identifies the smallest number of variables associated with self-reported shoulder complaints.

Workers highly exposed to psychosocial work risk factors and not physical work risk factors were 1.5 times more likely to report self-reported shoulder complaints compared to workers with low exposure to both of these factors.

Workers highly exposed to physical work risk factors and not to psychosocial work risk factors were approximately 2 times more likely to report problems compared to workers without high exposure to either physical or psychosocial work risk factors.

The greatest likelihood of reporting self-reported shoulder complaints was for workers highly exposed to both physical and psychosocial work risk factors. They were 3 times more likely to report problems compared to workers with neither set of factors. The confidence interval for the adjusted odds ratios for each exposure group suggested a true effect.

A tentative epidemiological interaction effect (AP=0.12 95%CI –0.16-0.41) was observed between physical and psychosocial work risk factors indicated by a departure from an additive model of risk.

The individual factors associated with self-reported shoulder complaints were age, gender, negative mood and low job satisfaction.

In summery, physical and psychosocial workplace factors and individual factors (gender, traits and well-being) were strongly associated with workers reporting self-reported shoulder complaints. The combined effects of high exposure to physical and psychosocial work risk factors increased the likelihood of reporting the outcome.

7.2 STAGE II ANALYSES FOR SELF-REPORTED SHOULDER COMPLAINTS

The stage I analyses showed the factors associated with self-reported shoulder complaints. The stage II analyses in this section were conducted in order to determine whether the factors associated with self-reported shoulder complaints in the stage I analyses also predicted new episodes of the outcome. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

At baseline, workers who did not report having shoulder problems in the last 12 months were selected for the follow-up cohort (2352 workers). In total 1701 (72%) responded to the follow-up questionnaire and were included in the prospective data analysis. The cumulative incidence of self-reported shoulder complaints was 13%.

Table 12 shows a comparison between the multivariate adjusted odds ratios obtained from the cross-sectional baseline study and the follow-up study.

Low physical and low psychosocial exposure was used as the reference group. The likelihood of reporting new episodes of self-reported shoulder complaints was greatest (OR 1.85) for workers highly exposed to both physical and psychosocial work risk factors compared to the reference group. There was a lesser increase in the likelihood for workers highly exposed to physical work risk factors and not highly exposed to psychosocial work risk factors. The group with low physical exposure but high psychosocial exposure had a lower odds ratio than the two groups with high physical exposure. An interaction effect between high exposure to physical and psychosocial work risk factors was not observed in the follow-up study.

Table 12 Comparing the likelihood of self-reported shoulder complaints for all subjects at baseline (N=2502) and for the cohort at follow-up, who did not report self-reported shoulder complaints at baseline for all variables in the mixed domain model (N=1389)

	Baseline study		***Follow-up study***	
	aOR	***(95% CI)***	***aOR***	***(95% CI)***
Low physical-low psychosocial exposure	1.00	-	1.00	-
Low physical-high psychosocial exposure	1.54	1.00-2.38	1.45	0.83-2.51
High physical-low psychosocial exposure	2.22	1.61-3.05	1.62	1.09-2.42
High physical-high psychosocial exposure	3.14	2.24-4.40	1.85	1.17-2.94
Age	1.40	1.12-1.75	1.53	1.11-2.12
Gender	1.54	1.23-1.93	1.72	1.25-2.37
Negative effect	1.52	1.21-1.91	1.09	0.79-1.49
Poor versus high job satisfaction	1.67	1.23-2.27	1.30	0.80-2.12

Age and gender predicted new episodes of self-reported shoulder complaints, however, negative mood and low job satisfaction were unlikely predictors.

Table 13 shows the univariate odds ratio (sOR) for perceived job stress, perceived life stress, mental strain, psychosomatic symptoms and depression. Univariate odds ratios (sOR) indicated that perceived life stress and psychosomatic symptoms increased the likelihood of reporting new episodes of self-reported shoulder complaints. The data also suggested that perceived job stress and depression increased the likelihood, but it was unclear whether these were true effects.

Each factor in table 13 was entered into a regression model with each physical/psychosocial exposure variable, age and gender. The adjusted odds ratios for perceived life stress and psychosomatic symptoms indicated an independent effect upon the likelihood of developing self-reported shoulder complaints. However, there was a marked reduction in the adjusted odds ratios for all factors indicating interrelationships.

Table 13 Comparing the likelihood of new episodes of self-reported shoulder complaints for subjects who did not report low shoulder complaints at baseline by individual reactivity measures, adjusted for age, gender, physical and psychosocial exposure combinations (N= 1326)

	Follow-up study			
	sOR	***(95% CI)***	***aOR***	***(95% CI)***
Perceived job stress	1.43	0.88-2.31	1.16	0.69-1.94
Perceived life stress	1.58	1.15-2.16	1.49	1.01-2.19
Mental strain	0.97	0.65-1.47	0.68	0.43-1.08
Psychosomatic symptoms	1.70	1.22-2.35	1.49	1.04-2.14
Depression	1.29	0.94-1.76	0.95	0.64-1.40

Table 14 Results from multivariate analyses for the relationship between physical and psychosocial work risk factors and new episodes of self-reported shoulder complaints with inclusion of potential intermediate individual reactions

Exposure factor	***Model I*** [a]	***Model II*** [b]	***Model III*** [c]
Low physical-low psychosocial	1.00	1.00	1.00
Low physical-high psychosocial	1.44 (0.84-2.45)	1.31 (0.76-2.25)	1.29 (0.75-2.21)
High physical-low psychosocial	1.44 (0.96-2.15)	1.42 (0.95-2.13)	1.39 (0.93-2.09)
High physical-high psychosocial	1.76 (1.12-2.78)	1.61 (1.01-2.55)	1.53 (0.96-2.44)

a Adjusted odds ratios and 95% CI for age and gender
b Adjusted odds ratios and 95% CI for age, gender, perceived job stress and perceived life stress
c Adjusted odds ratios and 95% CI for age, gender, perceived job stress, perceived life stress, psychosomatic symptoms

Referring to table 14, perceived job stress and perceived life stress were entered into a model

with each physical/psychosocial exposure combination, age and gender (model II). The adjusted odds ratios for this model were compared to the model with only the physical/psychosocial exposure combinations, age and gender (model I). Psychosomatic symptoms was entered into a model containing the factors in model II to observe changes in the adjusted odds ratios (model III).

The modelling revealed that there was unlikely to be an intermediate effect for perceived job stress. Adjusting for psychosomatic symptoms did not markedly effect the odds ratios for each exposure group. Psychosomatic symptoms and perceived life stress independently affected the likelihood of new episodes of self-reported shoulder complaints.

7.3 CONCLUSIONS ON SELF-REPORTED SHOULDER COMPLAINTS

The stage I analyses showed low social support, low reward, job future ambiguity and threat of harm/injury were psychosocial workplace factors associated with self-reported neck complaints. Working with the head/neck bent or twisted excessively, frequent or heavy lifting in awkward posture, repetitive wrist movements for much of the normal working day, repetitive arm movements, seated for 30 minutes or more without a break were physical workplace factors associated with self-reported shoulder complaints. Workers highly exposed to both physical and psychosocial work risk factors had the greatest likelihood of reporting shoulder complaints. A tentative interaction effect was observed between physical and psychosocial workplace risk factors. Lay beliefs about stress were not associated with self-reported shoulder complaints.

The prospective data analysis in stage II did confirm the relationship observed in the baseline data analyses in stage I. High exposure to physical and high psychosocial work risk factors resulted in the highest adjusted odds ratio. Age and gender increased the likelihood of new episodes of self-reported shoulder complaints.

The importance of individual reactivity was assessed in the development of new episodes of self-reported shoulder complaints. Psychosomatic symptoms and perceived life stress and were strong predictors of new episodes of self-reported shoulder complaints and had independent effects upon the outcome. These factors or perceived job stress did not have a marked intermediate role in the relationship between physical and psychosocial work risk factors and self-reported shoulder complaints.

8 SELF-REPORTED ELBOW/FOREARM COMPLAINTS

Factors within the work organisation domain, the psychosocial work domain, individual domain, the physical work domain and individual reactivity have all been implicated in the development of self-reported musculoskeletal complaints.

The analyses in this section are split into two stages. The stage I analyses were conducted to investigate whether organisational, physical, psychosocial or individual factors were associated with reporting self-reported elbow/forearm complaints in the baseline cross-sectional study. The stage II analyses were conducted to investigate whether the factors associated with self-reported elbow/forearm complaints in stage I also increased the likelihood of reporting this outcome in the follow-up study of workers who did not report complaints in the baseline cross-sectional study. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

The factors associated with the reporting of elbow/forearm complaints that also preceded and increased the likelihood of reporting new episodes would satisfy the criteria of association and time order indicating involvement in the causation of this outcome.

Of the 3139 subjects responding to the baseline study questionnaire, 3072 reported a rating on self-reported elbow/forearm complaints, defined as having problems more than three times or lasting more than one week in the previous year. About 9% reported such a problem, of which approximately:-

- 42% reported separate episodes of the elbow/forearm problems in the last year with a frequency of at least once a month.
- 29% experienced episodes of elbow/forearm pain which lasted between one week and more than six months, 37% reported that symptoms lasted between one day and one week.
- 56% experienced a elbow/forearm problem in the last seven days.
- 84% reported that symptoms were not present when they first started the present job.
- 28% rated their pain right now between three and five, on a pain scale with a score of five indicating intolerable pain and a score of one indicating no pain.
- 13% had missed work in the last year for at least one day due to the problem.

The outcome measure for self-reported elbow/forearm complaints included workers who experienced chronic and acute elbow problems who required work absence.

8.1 STAGE I ANALYSES FOR SELF-REPORTED ELBOW/FOREARM COMPLAINTS

This section describes the results of the domain specific regression models and the factors selected for inclusion into the mixed domain model.

All the factors from the organisational, physical, psychosocial and individual domains with adjusted domain-specific odds ratios and confidence intervals indicating a true effect (lower 95% confidence limit 0.90 or higher) were included in the mixed domain model.

Referring to table 1 in appendix 6, low decision latitude, low social support, high extrinsic effort, high intrinsic effort, low reward, high role conflict, high role ambiguity, job future ambiguity, frequent verbal abuse and the frequent threat of harm/injury were psychosocial work

factors univariately associated with self-reported elbow/forearm complaints. A tentative increase in the likelihood was observed for job demands and so was excluded from subsequent analyses. The exclusion of cases with missing data had little effect on the association between each psychosocial work risk factor and the outcome.

After adjustment for the effects of each factor upon the other, high exposure to low decision latitude, social support, reward, role conflict, job future ambiguity and threat of harm/injury was associated with self-reported elbow/forearm complaints. These variables were included in the mixed domain model.

A tentative increase in the likelihood was observed for extrinsic effort. Intrinsic effort, role ambiguity and verbal abuse were unlikely risk factors, as indicated by the odds ratio and confidence interval. All these factors were excluded in the mixed domain model. A considerable reduction was observed between the univariate and multivariate odds ratios for each factor. This suggested inter-relationships between the psychosocial work factors

The number of hours normally worked per week, working a late or night shift and travel time to work were not associated with self-reported elbow/forearm complaints. These factors were not included in subsequent analysis. Working flexible hours was associated with the outcome and was included in the mixed domain model.

Referring to table 2 in appendix 6, physical work factors univariately associated with self-reported elbow/forearm complaints were:-

- vibration from a power tool or machine that made the hands vibrate during the past week
- repetitive wrist movements for much of the normal working day
- repetitive arm movements
- working with the head/neck bent or twisted excessively
- lifting 6-15 kilograms greater than 10 times per hour or lifting greater than 16 kg at all and always/often working with the back in an awkward position
- performing work with a deviated or bent wrist position.

The exclusion of cases with missing data for these factors had little effect on the odds ratios. After adjustment for the effects of each factor upon the other, repetitive movements of the wrists for much of the normal working day, working with the head/neck bent or twisted excessively and lifting while working often in awkward postures were tentatively associated with the outcome. The other three factors showed a strong association and were included in the mixed domain model.

Referring to table 3 in appendix 6, age (an individual demographic factor), high scores on neuroticism, rumination, negative mood (individual trait factors) and low job satisfaction (individual well-being factors) were univariately associated with recurrent elbow/forearm problems. Low job satisfaction increased the likelihood of reporting elbow/forearm complaints. Gender did not have a univariate association with the outcome but remained in subsequent analyses as a potential confounder.

Referring to table 4 in appendix 6, the lay beliefs about causes and alleviation of stress univariately associated with self-reported elbow/forearm complaints were:-

- people whose work involves physical danger, like policeman, are often very stressed

- women are more stressed than men because their careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotion

The exclusion of cases with missing data had little effect on the odds ratios. Gender, negative mood and low job satisfaction were associated with self-reported elbow/forearm complaints in the adjusted analysis. These factors were included in the mixed domain model.

The psychosocial work risk factors that remained significant in the domain-specific multivariate model (low decision latitude, social support, reward, role conflict, job future ambiguity and threat of harm/injury) were used to create a psychosocial exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 or more factors).

The physical work risk factors that remained significant in the domain-specific multivariate model (vibration from a power tool or machine that made the hands vibrate during the past week, repetitive arm movements, performing work with a deviated or bent wrist position) were used to create a physical exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 factors).

The physical and psychosocial exposure variables were used to create four indicator variables for different combinations of exposure to physical and psychosocial work risk factors and are shown in the mixed domain model in table 15. It identifies the smallest number of variables associated with self-reported elbow/forearm complaints.

The mixed domain model is shown in table 15. It identifies the smallest number of variables associated with self-reported elbow/forearm complaints.

Workers highly exposed to psychosocial work risk factors and not physical work risk factors were 1.7 times more likely to report elbow/forearm complaints compared to workers with low exposure to both of these factors.

Workers highly exposed to physical work risk factors and not to psychosocial work risk factors were approximately 2 times more likely to report complaints compared to workers without high exposure to either physical or psychosocial work risk factors.

The greatest likelihood of reporting elbow/forearm complaints was for workers highly exposed to both physical and psychosocial work risk factors. They were 3.7 times more likely to report problems compared to workers with neither set of factors. The confidence interval for the adjusted odds ratios for each exposure group suggested a true effect.

A tentative epidemiological interaction effect was observed (AP=0.25 95%CI –0.22-0.72) between physical and psychosocial work risk factors indicated by a departure from an additive model of risk.

The only individual factor associated with self-reported elbow/forearm complaints was age. Gender, negative mood and low job satisfaction showed a tentative association with the outcome. Type of working hours was an unlikely true effect.

Summarising the results of the stage 1 analysis, physical and psychosocial workplace factors and age were associated with workers reporting self-reported elbow/forearm complaints. The combined effects of high exposure to physical and psychosocial work risk factors increased the likelihood of reporting the outcome.

8.2 STAGE II ANALYSES FOR SELF-REPORTED ELBOW/FOREARM COMPLAINTS

The stage I analyses showed the factors associated with self-reported elbow/forearm complaints. The stage II analyses in this section were conducted in order to determine whether the factors associated with these complaints in the stage I analyses also predicted new episodes of the outcome. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

At baseline, workers who did not report elbow/forearm complaints in the last 12 months were selected for the follow-up cohort (2713 workers). In total 1964 (72%) responded to the follow-up questionnaire and were included in the prospective data analysis. The cumulative incidence of self-reported elbow/forearm complaints was 8.5%.

Table 15 shows a comparison between the multivariate adjusted odds ratios obtained from the cross-sectional baseline study and the follow-up study.

Low physical and low psychosocial exposure was used as the reference group. The likelihood of reporting new episodes of self-reported elbow/forearm complaints was greatest (OR 2.12) for workers highly exposed to both physical and psychosocial work risk factors. There was a lesser increase in the likelihood for workers highly exposed to physical work risk factors and not highly exposed to psychosocial work risk factors. The group with low physical exposure but high psychosocial exposure had a lower odds ratio than the two groups with high physical exposure. An interaction effect between high exposure to physical and psychosocial work risk factors was observed in the follow-up study.

Table 15 Comparing the likelihood of self-reported elbow/forearm complaints for all subjects at baseline (N=2253) and for the cohort at follow-up who did not report self-reported elbow/forearm complaints at baseline for all factors in the mixed domain model (N=1446)

	Baseline study		***Follow-up study***	
	aOR	***(95% CI)***	***aOR***	***(95% CI)***
Low physical-low psychosocial exposure	1.00	-	1.00	-
Low physical-high psychosocial exposure	1.72	1.15-2.55	1.24	0.80-1.93
High physical-low psychosocial exposure	2.06	0.96-4.38	1.36	0.55-3.33
High physical-high psychosocial exposure	3.68	2.34-5.78	2.12	1.21-3.74
Fixed versus flexible hours	1.09	0.79-1.51	0.95	0.64-1.40
Age	2.30	1.66-3.21	1.66	1.12-2.46
Gender	1.35	0.98-1.86	0.98	0.66-1.47
Negative mood	1.35	0.98-1.85	1.18	0.81-1.74
Job satisfaction	1.48	0.98-2.23	1.02	0.56-1.85

Age predicted new episodes of self-reported elbow/forearm complaints. Gender, negative mood, low job satisfaction and type of working hours were unlikely predictors.

Table 16 shows the univariate odds ratio (sOR) for perceived job stress, perceived life stress, mental strain, psychosomatic symptoms and depression. Univariate odds ratios (sOR) indicated that depression increased the likelihood of reporting new episodes of self-reported elbow/forearm complaints. The data also suggested that perceived job stress increased the likelihood but it was unclear whether this was a true effect.

Each factor in table 16 was entered into a regression model with each physical/psychosocial exposure variable, age and gender. The adjusted odds ratios for depression indicated an independent effect upon the likelihood of developing self-reported elbow/forearm complaints.

Table 16 Comparing the likelihood of new episodes of self-reported elbow/forearm complaints for subjects who did not report these complaints at baseline by individual reactivity measures adjusted for age, gender, physical and psychosocial exposure combinations (N= 1392)

	Follow-up study			
	sOR	***(95% CI)***	***aOR***	***(95% CI)***
Perceived job stress	1.49	0.85-2.60	1.35	0.73-2.47
Perceived stress	0.95	0.64-1.40	0.73	0.45-1.18
Mental strain	0.99	0.60-1.63	0.82	0.46-1.46
Psychosomatic symptoms	1.01	0.66-1.54	0.90	0.57-1.43
Depression	1.47	0.99-2.18	1.69	1.06-2.72

Table 17 Results from multivariate analyses for the relationship between physical and psychosocial work risk factors and new episodes of self-reported elbow/forearm complaints with inclusion of potential intermediate individual reactions

Exposure factor	***Model I*** [a]	***Model II*** [b]	***Model III*** [c]
Low physical-low psychosocial	1.00	1.00	1.00
Low physical-high psychosocial	1.35 (0.87-2.10)	1.34 (0.85-2.12)	1.28 (0.81-2.03)
High physical-low psychosocial	1.21 (0.46-3.20)	1.21 (0.46-3.18)	1.22 (0.46-3.22)
High physical-high psychosocial	2.03 (1.12-3.66)	2.02 (1.10-3.70)	1.87 (1.02-3.46)

a Adjusted odds ratios and 95% CI for age and gender
b Adjusted odds ratios and 95% CI for age, gender, perceived job stress and perceived life stress
c Adjusted odds ratios and 95% CI for age, gender, perceived job stress, perceived life stress, depression

Referring to table 17, perceived job stress and perceived life stress were entered into a model with each physical/psychosocial exposure combination, age and gender (model II). The adjusted odds ratios for this model were compared to the model with only the physical/psychosocial exposure combinations, age and gender (model I). Depression was

entered into a model containing the factors in model II to observe changes in the adjusted odds ratios (model III).

The modelling revealed that there was unlikely to be an intermediate effect for perceived job stress and perceived life stress. Adjusting for depression did not markedly effect the odds ratios for each exposure group. Depression independently affected the likelihood of new episodes of self-reported elbow/forearm complaints.

8.3 CONCLUSIONS ON SELF-REPORTED ELBOW/FOREARM COMPLAINTS

The stage I analyses showed that low decision latitude, social support, reward, role conflict, job future ambiguity and threat of harm/injury were psychosocial workplace factors associated with self-reported elbow/forearm complaints. Vibration from a power tool or machine that made the hands vibrate during the past week, repetitive arm movements and performing work with a deviated or bent wrist position were physical workplace factors associated with self-reported elbow/forearm complaints. Workers highly exposed to both physical and psychosocial work risk factors had the greatest likelihood of reporting elbow/forearm complaints. A tentative epidemiological interaction effect was observed between physical and psychosocial work risk factors. Lay beliefs about stress were not associated with self-reported elbow/forearm complaints.

The prospective data analysis in stage II did confirm the relationship observed in the baseline data analyses in stage I. High exposure to physical and psychosocial work risk factors resulted in the highest adjusted odds ratio. Age was the only individual factor that increased the likelihood of new episodes of self-reported elbow/forearm complaints.

The importance of individual reactivity was assessed in the development of new episodes of self-reported elbow/forearm complaints. Depression was the only strong predictor of new episodes of these complaints. Perceived job stress was unlikely to play an intermediate role in the relationship between physical and psychosocial workplace risk factors and self-reported elbow/forearm complaints.

9 SELF-REPORTED HAND/WRIST COMPLAINTS

Factors within the work organisation domain, the psychosocial work domain, individual domain, the physical work domain and individual reactivity have all been implicated in the development of self-reported musculoskeletal complaints.

The analyses in this section are split into two stages. The stage I analyses were conducted to investigate whether organisational, physical, psychosocial or individual factors were associated with reporting self-reported hand/wrist complaints in the baseline cross-sectional study. The stage II analyses were conducted to investigate whether the factors associated with self-reported hand/wrist complaints in stage I also increased the likelihood of reporting this outcome in the follow-up study of workers who did not report complaints in the baseline cross-sectional study. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

The factors associated with the reporting of hand/wrist complaints that also preceded and increased the likelihood of reporting new episodes would satisfy the criteria of association and time order indicating involvement in the causation of this outcome.

Of the 3139 subjects responding to the baseline study questionnaire, 3089 reported a rating on self-reported hand/wrist complaints, defined as having problems more than three times or lasting more than one week in the previous year. About 18% reported such a problem of which approximately:-

- 51% reported separate episodes of the hand/wrist problems in the last year with a frequency of at least once a month.
- 37% reported that symptoms lasted between one day and one week, 18% experienced episodes of hand/wrist pain which lasted more than one week.
- 50% experienced a hand/wrist problem in the last seven days.
- 77% reported that symptoms were not present when they first started the present job.
- 20% rated their pain right now between three and five on a pain scale with a score of five indicating intolerable pain and a score of one indicating no pain.
- 38% reported that their hand/wrist pain extended up their arm.
- 12% reported that the hand/wrist problems started after a sudden injury to the hand/wrist such as whiplash or fracture.
- 21% reported that there problem wakes them from sleep.
- 40% had difficulty opening jars.
- 39% had gone for treatment for the problem in the last year.
- 5% had undergone surgery for the problem.
- 12% had missed work in the last year for at least one day due to the problem.
- 17% had to perform light or restricted work in the last year because of their low hand/wrist problem.
- 27% reported they had difficulty maintaining their normal work pace because of the problem.
- 75 % reported that specific activities at work made the problem worse.

The outcome measure for self-reported hand/wrist complaints used in this study included workers who experienced chronic and acute hand/wrist problems, sought medical attention and required work absence, restricted duty or had difficulty performing work.

9.1 STAGE I ANALYSES FOR SELF-REPORTED HAND/WRIST COMPLAINTS

This section describes the results of the domain specific regression models and the factors selected for inclusion into the mixed domain model.

All the factors from the organisational, physical, psychosocial and individual domains with adjusted domain-specific odds ratios and confidence intervals indicating a true effect (lower 95% confidence limit 1.00 or higher) were included in the mixed domain multivariate model.

Referring to table 1 in appendix 7, low decision latitude, low social support, high intrinsic effort, low reward, job future ambiguity and the frequent threat of harm/injury were psychosocial work factors univariately associated with self-reported hand/wrist complaints. A tentative increase in the likelihood was observed for job demands, extrinsic effort, high role conflict and frequent verbal abuse so these factors were excluded from subsequent analyses. The exclusion of cases with missing data had little effect on the association between each psychosocial work risk factor and the outcome.

After adjustment for the effects of each factor upon the other, high exposure to intrinsic effort, role ambiguity and job future ambiguity was associated with self-reported hand/wrist complaints. These factors were included in the mixed domain model.

A tentative increase in the likelihood was observed for reward and threat of harm/injury. Decision latitude and social support were unlikely risk factors. All these factors were excluded in the mixed domain model. A considerable reduction was observed between the univariate and multivariate odds ratios for each factor. This suggested inter-relationships between the psychosocial work factors.

The number of hours normally worked per week, working a late or night shift and travel time to work were not associated with self-reported hand/wrist complaints. These factors were not included in subsequent analysis. Working fixed as opposed to flexible hours was associated with the outcome and so was included in the mixed domain model.

Referring to table 2 in appendix 7, physical work factors univariately associated with self-reported hand/wrist complaints with an odds ratio and confidence interval indicating a true effect were:-

- vibration from a power tool or machine that made the hands vibrate during the past week
- repetitive wrist movements for much of the normal working day
- repetitive arm movements
- working with the head/neck bent or twisted excessively
- using a keyboard more than four hours per day
- performing work with a deviated or bent wrist position.

The exclusion of cases with missing data for these factors had little effect on the odds ratios. After adjustment for the effects of each factor upon the other, working with the head/neck bent or twisted excessively was tentatively associated with the outcome. The other five factors

showed a strong association and were included in the mixed domain model.

Referring to table 3 in appendix 7, gender (an individual demographic factor), high scores on neuroticism, rumination, positive and negative effect (individual trait factors), life and job satisfaction (individual well-being factors) were univariately associated with self-reported hand/wrist complaints. Being satisfied with your life and having a positive mood reduced the likelihood. Low job satisfaction increased the likelihood of self-reported hand/wrist complaints. Age had a tentative univariate association with the outcome but remained in subsequent analyses as a potential confounder (appendix 7, table 3).

Referring to table 4 in appendix 7, the lay beliefs about causes and alleviation of stress univariately associated with self-reported hand/wrist complaints, with an odds ratio were:-

- people who work for others, or who have to consult colleagues are more stressed because they must constantly follow other people's decisions, routines and ways of working
- the person is stressed mainly because he/she isn't satisfied by his/her job
- if an organisation as a lot of young employees, older ones tend to feel threatened by this, which leads to stress
- women are more stressed that men at work because there careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotions
- a woman will be more stressed at work because of male attitudes towards female bosses or colleagues create a difficult and constantly challenging climate
- reducing stress depends on a person's general ability to overcome problems
- reducing stress depends on how much self-control the person has
- reducing stress depends on how embarrassed the person feels about having the problem.

The exclusion of cases with missing data had little effect on the odds ratios. Gender, neuroticism, poor job satisfaction and the following beliefs were associated with self-reported hand/wrist complaints in the adjusted analysis:-

- the person is stressed mainly because he/she isn't satisfied by his/her job
- a woman will be more stressed at work because of male attitudes towards female bosses or colleagues create a difficult and constantly challenging climate

-

The psychosocial work risk factors that remained significant in the domain-specific multivariate model (intrinsic effort, role ambiguity and job future ambiguity) were used to create a psychosocial exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 or more factors).

The physical work risk factors that remained significant in the domain-specific multivariate model (vibration from a power tool or machine that made the hands vibrate during the past week, repetitive wrist movements for much of the normal working day, repetitive arm movements, using a keyboard more than four hours per day and performing work with a deviated or bent wrist position) were used to create a physical exposure variable. This variable was formed by summing the number of high exposure factors to create a sum score. This score was dichotomised into low and high exposure (an exposure cut-off at 2 factors).

The physical and psychosocial exposure variables were used to create four indicator variables

for different combinations of exposure to physical and psychosocial work risk factors and are shown in the mixed domain model in table 18. It identifies the smallest number of variables associated with self-reported hand/wrist complaints.

Workers highly exposed to psychosocial work risk factors and not physical work risk factors were 1.2 times more likely to report self-reported hand/wrist complaints compared to workers with low exposure to both of these factors.

Workers highly exposed to physical work risk factors and not to psychosocial work risk factors were approximately 2.4 times more likely to report problems compared to workers without high exposure to either physical or psychosocial work risk factors.

The greatest likelihood of reporting self-reported hand/wrist complaints was for workers highly exposed to both physical and psychosocial work risk factors. They were 3.1 times more likely to report problems compared to workers with neither set of factors. The confidence interval for the adjusted odds ratios for the two high physical exposure groups suggested a true effect.

A tentative epidemiological interaction effect was observed (AP 0.17 95%CI –0.10-0.44) between physical and psychosocial work risk factors indicated by a departure from an additive model of risk.

The individual factors associated with self-reported hand/wrist complaints were age, gender, neuroticism and low job satisfaction (tentative association). The two subjective beliefs about the causes of stress were also associated with the outcome. The type of working hours was an unlikely risk factor.

Summarising the results of the stage 1 analysis, physical and psychosocial workplace factors and individual factors (gender, traits, attitudes and well-being) were associated with workers reporting self-reported hand/wrist complaints. The combined effects of high exposure to physical and psychosocial work risk factors increased the likelihood of reporting the outcome.

9.2 STAGE II ANALYSES FOR SELF-REPORTED HAND/WRIST COMPLAINTS

The stage I analyses showed the factors associated with self-reported hand/wrist complaints. The stage II analyses in this section were conducted in order to determine whether the factors associated with these complaints in the stage I analyses also predicted new episodes of the outcome. In addition, the effects of perceived job stress and other individual reactivity measures on the development of the outcome were also investigated.

At baseline, workers who did not report hand/wrist complaints in the last 12 months were selected for the follow-up cohort (2330 workers). In total 1693 (73%) responded to the follow-up questionnaire and were included in the prospective data analysis. The cumulative incidence of self-reported hand/wrist complaints was 11%.

Table 18 shows a comparison between the multivariate adjusted odds ratios obtained from the cross-sectional baseline study and the follow-up study.

Low physical and low psychosocial exposure was used as the reference group. The likelihood of reporting new episodes of self-reported hand/wrist complaints was greatest (OR 3.35) for workers highly exposed to both physical and psychosocial work risk factors. There was a lesser increase in the likelihood for workers highly exposed to physical work risk factors and not highly exposed to psychosocial work risk factors. The group with low physical exposure but

high psychosocial exposure had a similar odds ratio to the high physical-low psychosocial exposure group. The odds ratio and confidence interval for each exposure group indicated a true effect. An interaction effect between high exposure to physical and psychosocial work risk factors was not observed in the follow-up study.

Table 18 Comparing the likelihood of self-reported hand/wrist complaints for all subjects at baseline (N=2157) and for the cohort at follow-up, who did not report self-reported hand/wrist complaints at baseline for all factors in the final model (N=1162)

	Baseline study		***Follow-up study***	
	aOR	***(95% CI)***	***aOR***	***(95% CI)***
Low physical-low psychosocial exposure	1.00	-	1.00	-
Low physical-high psychosocial exposure	1.22	0.77-1.93	2.10	1.11-3.96
High physical-low psychosocial exposure	2.41	1.69-3.43	1.94	1.10-3.42
High physical-high psychosocial exposure	3.13	2.19-4.49	3.35	1.91-5.88
Fixed versus flexible hours	0.97	0.76-1.22	1.11	0.75-1.64
Age	1.26	1.00-1.59	1.39	0.94-2.04
Gender	1.34	1.06-1.70	0.68	0.49-1.04
Neuroticism	1.44	1.13-1.85	1.28	0.86-1.91
Poor versus high job satisfaction	1.31	0.93-1.84	0.93	0.50-1.73
The person is stressed mainly because he/she isn't satisfied by his/her job	1.43	1.13-1.80	0.82	0.56-1.22
A woman will be more stressed at work because of male attitudes towards female bosses or colleagues create a difficult and constantly challenging climate	1.52	1.17-1.98	1.16	0.73-1.86

None of the individual or organisational factors in the mixed domain model were predictors of new episodes of self-reported hand/wrist complaints.

Table 19 shows the univariate odds ratio (sOR) for perceived job stress, perceived life stress, mental strain, psychosomatic symptoms and depression. Univariate odds ratios (sOR) indicated that mental strain, psychosomatic symptoms, depression and perceived life stress increased the likelihood of reporting new episodes of self-reported hand/wrist complaints. Perceived job stress was a tentative predictor of self-reported hand/wrist complaints.

Each factor in table 19 was entered into a regression model with each physical/psychosocial exposure variable, age and gender. The adjusted odds ratios for psychosomatic symptoms indicated an independent effect upon the likelihood of developing self-reported hand/wrist complaints. However, there was a marked reduction in the adjusted odds ratios for all factors indicating interrelationships.

Table 19 Comparing the likelihood of new episodes of self-reported hand/wrist complaints for subjects who did not report hand/wrist problems at baseline by individual reactivity measures adjusted for age, gender, physical and psychosocial exposure combinations (N= 1125)

	Follow-up study			
	sOR	***(95% CI)***	***aOR***	***(95% CI)***
Perceived job stress	1.35	0.77-2.37	0.83	0.45-1.52
Perceived stress	1.67	1.14-2.44	1.19	0.74-1.92
Mental strain	1.63	1.07-2.50	0.94	0.56-1.58
Psychosomatic symptoms	2.19	1.49-3.21	1.82	1.20-2.77
Depression	1.82	1.25-2.67	1.26	0.78-2.05

Table 20 Results from multivariate analyses for the relationship between physical and psychosocial work risk factors and new episodes of self-reported hand/wrist complaints with inclusion of potential intermediate individual reactions

Exposure factor	***Model I*** [a]	***Model II*** [b]	***Model III*** [c]
Low physical-low psychosocial	1.00	1.00	1.00
Low physical-high psychosocial	2.38 (1.27-4.46)	2.15 (1.13-4.08)	2.05 (1.07-3.91)
High physical-low psychosocial	2.03 (1.14-3.61)	2.05 (1.15-3.64)	1.96 (1.10-3.51)
High physical-high psychosocial	3.77 (2 .15-6.60)	3.42 (1.93-6.08)	3.14 (1.76-5.61)

a Adjusted odds ratios and 95% CI for age and gender
b Adjusted odds ratios and 95% CI for age, gender, perceived job stress and perceived life stress
c Adjusted odds ratios and 95% CI for age, gender, perceived job stress, perceived life stress, psychosomatic symptoms

Referring to table 20, perceived job stress and perceived life stress were entered into a model with each physical/psychosocial exposure combination, age and gender (model II). The adjusted odds ratios for this model were compared to the model with only the physical/psychosocial exposure combinations, age and gender (model I). Psychosomatic symptoms was entered into a model containing the factors in model II to observe changes in the adjusted odds ratios (model III).

The modelling revealed that there was likely to be an intermediate effect for perceived stress for the high psychosocial exposure groups. Psychosomatic symptoms also had an effect on the adjusted odds ratio for the high psychosocial exposure groups. Psychosomatic symptoms may also play an intermediate role between high exposure to physical and psychosocial workplace risk factors and the outcome.

9.3 CONCLUSIONS ON SELF-REPORTED HAND/WRIST COMPLAINTS

The stage I analyses showed that intrinsic effort, role ambiguity and job future ambiguity were psychosocial workplace factors associated with self-reported hand/wrist complaints. Vibration from a power tool or machine that made the hands vibrate during the past week, repetitive wrist movements for much of the normal working day, repetitive arm movements, using a keyboard more than four hours per day and performing work with a deviated or bent wrist position were physical workplace factors associated with self-reported hand/wrist complaints. Workers highly exposed to both physical and psychosocial work risk factors had the greatest likelihood of reporting hand/wrist complaints. A tentative interaction effect between physical and psychosocial workplace risk factors was observed. Age, gender and neuroticism were associated with self-reported hand/wrist complaints. The beliefs that stress is caused by low job satisfaction and woman will be more stressed at work because of male attitudes were also associated with self-reported hand/wrist complaints.

The prospective data analysis in stage II did confirm the relationship observed in the baseline data analyses in stage I. High exposure to physical and psychosocial work risk factors resulted in the greatest adjusted odds ratio. A tentative relationship between age and new episodes of self-reported hand/wrist complaints was observed. Lay beliefs about stress, gender, neuroticism and low job satisfaction did not increased the likelihood of self-reported hand/wrist complaints.

The importance of individual reactivity was assessed in the development of new episodes of self-reported hand/wrist complaints. Only psychosomatic symptoms increased the likelihood. Perceived job stress and perceived life stress were likely to play an intermediate role in the relationship between high exposure to psychosocial workplace risk factors and self-reported hand/wrist complaints. Psychosomatic symptoms were likely to play an intermediate role in the relationship between high exposure to physical and psychosocial workplace risk factors and self-reported hand/wrist complaints.

10 DISCUSSION

This epidemiological study was designed to investigate the role of stress and other psychological factors upon the development of musculoskeletal disorders. Musculoskeletal disorders are multifactorial in aetiology and so work organisation factors, physical workplace factors, psychosocial workplace factors, individual factors and stress reactions were investigated.

A baseline cross-sectional study and follow-up study were conducted to address the nine specific study objectives described in section 2 of this report. In order to present the results of the first four study objectives coherently, the report addressed the factors that were associated with high perceived job stress and then identified whether these factors also increased the likelihood of high perceived job stress developed during the follow-up period.

Likewise for objectives 5-9, the report then addressed the factors associated with self-reported musculoskeletal complaints in the baseline cross-sectional study and then identified whether these factors increased the likelihood of reporting new episodes of these complaints in the follow-up study. The results for self-reported musculoskeletal complaints were presented separately for the lower back, upper back, neck, shoulders, elbows/forearms and hands/wrists.

The analyses conducted in this report have been designed to establish factors that may cause perceived job stress and self-reported musculoskeletal complaints. No single epidemiological study will fulfil all the criteria for causality but the analyses in this study attempted to address two fundamental criteria – association and time order. There must be an association between the exposure and the outcome and the exposure must also precede the outcome (Susser, 1991).

There are other important criteria that must also be satisfied to establish causality but are not addressed in detail in this report – consistency of a repeated association in a number of studies, evidence of an exposure-response relationship and coherence of evidence in that there is biological plausibility for the relationships observed.

This study has many strengths. Most importantly, it addresses association and time order. Also, numerous stress reactions and musculoskeletal complaints in various body regions have been measured. Psychometrically tested and validated measures have been used for measuring exposures and outcomes. And finally, a broad range of occupational groups has been included in the study population.

10.1 POTENTIAL BIAS IN THE STUDY

However, as with all studies of this kind there are biases that may have affected the results.

The cross-sectional data could have been subject to a healthy worker effect, whereby individuals who developed work-related stress or musculoskeletal complaints before the study may have left the workforce or may have changed jobs to substantially alter exposure to a number of workplace risk factors.

The presence of a healthy worker effect would have made it more difficult to detect a true effect between potential risk factors and the outcomes in this study.

A response bias was also possible in that workers not responding to the baseline cross-sectional study did so because they were stressed at work and experienced musculoskeletal problems. In the cross-sectional study, data on perceived job stress and musculoskeletal complaints was

obtained from a sample of non-respondents. There was no indication in the sample that respondents differed to non-respondents in the reporting of musculoskeletal complaints (data not shown). Non-respondents did have a slightly higher prevalence in reporting high perceived job stress. It may be that there is an underestimation in the prevalence of high perceived job stress in the study sample. The prevalence of high perceived job stress in this study (12%) was lower than the prevalence obtained in the Bristol Stress and Health at Work Study (18.5%) (Smith et al., 2000). It was not clear in this study whether the non-respondents were representative of all non-respondents. An underestimate in the prevalence of high perceived job stress and musculoskeletal complaints would have made it harder to detect a true effect between potential risk factors and outcomes.

Respondents to the baseline survey did not differ with non-respondents with respect to age or gender in the sample population. However, responses were generally lower in organisations employing blue collar workers so the respondents included more white collar workers (70% of respondents).

The possibility of bias due to selective loss of subjects in the follow-up study would have reduced the ability to detect a true effect between potential risk factors and outcomes. However, the response rate in the follow-up study was high and so the effect of this bias is probably limited.

In the baseline cross-sectional survey, workers were classified into low and high physical/ psychosocial exposure groups. The follow-up study required workers to maintain exposure status for the duration of the follow-up period. During the follow-up, there was a potential for workers to report greater mental workload. Despite this, the classification of workers into low and high psychosocial exposure groups remained relatively unchanged. There was good agreement between physical and psychosocial exposure measures taken 6 months apart (see section 1.3 in appendix 10). The misclassification of exposure would generally mask the true effect between potential risk factors and outcomes if the misclassification rate was equal for workers with and without each outcome.

Accurately collecting exposure and outcome information from questionnaires can be a problem in large scale epidemiological studies. However, problems of accuracy in exposure assessment can be reduced by categorising workers into two broad exposure groups with good contrast in exposure between the two groups. The pilot study assisted in minimising potential problems with response accuracy (see appendix 9). In addition, any associations between risk factors and outcomes in the study may be partly due to the fact that self-report questions have been used to collect all information in the epidemiological study. However, small scale validation work on some of the physical and psychosocial exposure questions in this study showed adequate sensitivity and specificity (see appendix 10).

In regard to measuring musculoskeletal complaints, the outcome measures used in this study have been shown to have good to excellent test-retest reliability and are considered suitable for use in epidemiological studies. In addition, physical examinations conducted on a small group of subjects from the cohort indicated that subjects reporting musculoskeletal complaints had an increased likelihood of having problems with activities of daily living. The outcome measures were also good at identifying subjects without musculoskeletal complaints and less accurate at identifying subjects with musculoskeletal complaints. However, this may have partly been due to the fact that some subjects were not in pain at the time of the clinical examination but had an ongoing musculoskeletal problem over the last year.

Confounders such as age, gender, neuroticism were measured in this study and were controlled for in the multivariate analyses. It is presumed, for example, that people with high scores on

neuroticism are more likely to report stressors and distress, discomfort and dissatisfaction irrespective of their environment (Jones & Bright, 2001). In the cross-sectional study, an association between a high score on neuroticism and high perceived job stress was observed. However, a high score on neuroticism, age or gender did not increase the likelihood of reporting high perceived job stress in the follow-up study of workers who had developed the outcome during the follow-up period. High exposure to psychosocial workplace factors did increase the likelihood. Therefore, it is unlikely that neuroticism confounded the relationships observed in the follow-up study.

10.2 RISK FACTORS FOR WORK-RELATED STRESS

Individual factors such as age, gender, neuroticism, rumination and lay beliefs about the causes and alleviation of stress were associated with reporting high perceived job stress but did not increase the likelihood of reporting this outcome in the follow-up study.

In the base-line cross-sectional study, workers highly exposed to physical and psychosocial work risk factors had the greatest likelihood of reporting high perceived job stress. However, a tentative interaction effect between physical and psychosocial workplace risk factors was observed in the base-line cross-sectional study. In the follow-up study, high exposure to both physical and psychosocial work risk factors did not increase the likelihood of reporting high perceived job stress.

The psychosocial work factors associated with reporting high perceived job stress in the cross-sectional study and which also increased the likelihood of reporting the outcome in the follow-up study were extrinsic effort, intrinsic effort, role conflict and verbal abuse or confrontations with clients or the general public.

Extrinsic effort concerns job demands such as constant time pressure, interruptions and disturbances at work, job responsibility, pressure to work overtime and increasing demands of the job. The study by Smith et al. (2000) showed that each of these factors forming extrinsic effort were univariately associated with high perceived job stress (Smith et al., 2000).

It has been recognised that the stress is partly dependent on the individual's ability to cope and on the way in which they cope with the experienced stressors (Cox et al., 2000). Intrinsic effort in this study refers to an individual coping pattern characterised by being overwhelmed by time pressures, inability to relax and switch off after work and sacrificing too much for the job.

Role conflict concerns the need to do things differently, dealing with incompatible requests, conflict with personal values and having assignments without adequate resources. Verbal abuse or confrontations with clients or the general public also implies conflict but with external relations outside of the work organisation.

All these factors are recognised in the scientific literature as factors in the workplace linked to work related stress (Cox et al., 2000). Other psychosocial work factors such as role ambiguity, social support, rewards, job future ambiguity, decision latitude and threat of physical harm or injury were either not associated with the reporting of high perceived job stress or did not increase the likelihood of reporting the onset of this outcome in the follow-up study.

10.3 COMPARISON OF THE STRESS RESULTS WITH OTHER STUDIES

Some of the results from the study are supported by a previous epidemiological study funded by

the HSE. The study by Smith et al. (2000) showed that psychosocial work factors increased the likelihood of reporting high perceived job stress in a population of workers from the Bristol area in the UK. The results from the study by Smith et al. are not directly comparable to the results of this study. The previous study did not include multivariate analyses of psychosocial work factors and did not exclude workers who reported high perceived job stress in the follow-up study.

Another major prospective epidemiological study funded by the HSE showed, after adjustment in multivariate analyses, that psychosocial work factors (high job demands, low decision latitude and low social support) increased the likelihood of reporting psychiatric disorder at follow-up in a cohort of civil servants (Stansfeld et al., 2000). The present study and the study by Stansfeld et al. are not directly comparable because the present study measured a related outcome and the study population included workers from every major occupational category. Despite this, both studies showed consistency in that psychosocial factors predicted stress reactions.

10.4 HEALTH OUTCOMES ASSOCIATED WITH PERCEIVED JOB STRESS

Compared to workers with low to moderate job stress, workers with high perceived job stress were 1.5 times more likely to take more than 5 days off work because of health reasons. There was little evidence that high job stress was associated with time off work for health reasons for short periods (less than 5 days). Workers with high perceived job stress were:-

- 5 times more likely to report mental strain
- 4 times more likely to report depression
- 4 times more likely to report psychosomatic health complaints

An investigation into the relationship between different stress reactions was beyond the scope of this study but should be the subject of further research.

10.5 RISK FACTORS FOR SELF-REPORTED MUSCULOSKELETAL COMPLAINTS

High exposure to physical and psychosocial work risk factors was associated with self-reported low-back, upper back, neck, shoulder, elbow/forearm and hand/wrist musculoskeletal complaints. A tentative interaction effect between physical and psychosocial workplace risk factors was observed for the lower back, the neck, the shoulder, the elbow/forearm and the hand/wrists but not for the upper back.

High exposure to physical and psychosocial work risk factors also increased the likelihood of reporting new episodes of self-reported low-back, neck, shoulder, elbow/forearm and hand/wrist complaints. High exposure to physical and psychosocial work risk factors did not increase the likelihood of new episodes of upper back complaints.

Generally, lay beliefs about the causes and alleviation of stress were not associated with self-reported musculoskeletal complaints. In addition, these lay beliefs did not increase the likelihood of reporting new episodes of self-reported musculoskeletal complaints.

In general, individual factors (demographics, trait and well-being) did not satisfy both criteria of association and time order in order to be implicated in causation of self-reported musculoskeletal complaints. However, age and gender did satisfy association and time order for self-reported shoulder complaints. Age also satisfied association and time order for self-reported elbows/forearm complaints.

Stress reactions were measured using perceived job stress, perceived life stress, mental strain, depression and psychosomatic symptoms.

Psychosomatic symptoms increased the likelihood of reporting new episodes of self-reported upper back, shoulder and hand/wrist complaints. Depression increased the likelihood of new episodes of self-reported musculoskeletal complaints affecting the upper back, neck and elbows/forearms. Perceived life stress increased the likelihood of new episodes of self-reported shoulder complaints.

Perceived job stress did not increase the likelihood of new episodes of self-reported musculoskeletal complaints. However, it was involved as an intermediate factor between high exposure to physical and psychosocial work risk factors and the outcome for the low-back, the upper back and hands/wrists.

Interventions designed to reduce the risk of self-reported musculoskeletal complaints need to consider the degree of exposure to physical work risk factors and psychosocial work risk factors and the individual stress reactions that workers may be experiencing.

10.6 COMPARISON OF THE STUDY WITH OTHER STUDIES ON MUSCULOSKELETAL DISORDERS

Most of the epidemiology on stress and musculoskeletal disorders has used a cross-sectional study design that is limited in establishing time order. None the less a link between stress and musculoskeletal disorders has been shown (Bongers et al., 2002; Davis & Heaney, 2000; National Research Council & Institute of Medicine, 2001).

High exposure to a combination of physical and psychosocial work risk factors has been implicated in the development of musculoskeletal disorders in a number of cross-sectional studies or case-control studies (Bildt Thorbjörnsson et al., 1998; Devereux et al., 1999; Devereux et al., 2002; Fredriksson et al., 2000; Kerr et al., 2001; MacDonald et al., 2001; Warren et al., 2000). However, it has been unclear whether these potential combined effects may increase the risk of developing musculoskeletal disorders due to the limited designs of these studies.

This is the first prospective epidemiological study to show that high exposure to a combination of physical and psychosocial work risk factors produced the greatest risk of developing new episodes of self-reported musculoskeletal complaints, in a number of different body regions, compared to being exposed to either one or the other set of factors in a large mixed work population while adjusting for various stress reactions.

Two previous prospective studies in the UK have shown a relationship between perceived stress due to work and self-reported low-back disorder symptoms (Harkness et al., 2003; Smith et al., 2000). Only the study by Harkness et al. adjusted for the effects of other factors. After adjustment, there was a tentative increase in the likelihood of reporting the onset of low-back pain for workers reporting stressful work at least half of the time compared to never/occasionally. The results from the present study also showed a tentative increase in the likelihood of new episodes of self-reported low-back complaints for workers reporting very or extremely stressful jobs compared to workers with moderate to non-stressful jobs.

Only one previous prospective study has been identified that has investigated the relationship between perceived stress and self-reported neck or shoulder symptoms. High levels of

perceived mental stress predicted new cases of shoulder pain after adjustment for physical work factors, leisure and demographics (Miranda et al., 2001). The result in the present study showed that perceived life stress increased the likelihood of reporting new episodes of self-reported shoulder complaints.

Only one previous prospective study has been identified that investigated the relationship between work-related stress and self-reported hand/wrist problems. The study by McFarlane et al. (2000) did not show an independent effect of perceived job stress after adjustment for other factors. The results of the present study also showed that perceived job stress was unlikely to act independently. However, there was evidence to suggest that perceived job stress and life stress may act as intermediate factors between exposure and outcome.

Previous prospective studies have not shown a relationship between depression or anxiety and low-back disorders (Leino, 1989; Pietri-Taleb et al., 1995; Verbeek & Verbeek, 1999). Depression or anxiety measured in the present study did not increase the likelihood of reporting low-back complaints. However, depression did increase the likelihood of developing self-reported neck complaints. This finding has also been observed in two other prospective studies (Leino, 1989; Leino & Magni, 1993; Pietri-Taleb et al., 1994).

Psychosomatic symptoms have been shown to increase the likelihood of developing hand/wrist problems in two previous prospective studies (Feveile et al., 2002; Leino, 1989). In the present study, psychosomatic symptoms also increased the likelihood of reporting new episodes of self-reported hand/wrist complaints.

There are few prospective studies available with which to compare the results of the present study. However, the available evidence does support these findings.

There are plausible mechanisms to support a relationship between work-related stress or mental stress reactions and musculoskeletal disorders. Being exposed to both physical or psychosocial workplace risk factors may result in certain physical and mental reactions depending on an individual's capacity to perform work. Exposure to both physical and psychosocial workplace risk factors may exacerbate the physical and mental reactions greater than the sum of the independent effects of each set of factors. That is to say a synergistic effect or an interaction from exposure to both sets of factors may increase the likelihood of developing musculoskeletal disorders (Devereux et al., 1999; Devereux et al., 2002).

Mental stress reactions may limit the ability of the body's defences and repair systems to deal with the physical reactions leading to damage to the musculoskeletal system (Lundberg, 2002). Therefore, it may take longer to recover from musculoskeletal disorders. Additionally, mental stress reactions may increase exposure to workplace risk factors for musculoskeletal disorders (Marras et al., 2000). For example, a delivery driver may handle boxes very rapidly because of a mental stress reaction to time pressure, thus placing excessive physical strain on the body because of the excessive speed of movement and the excess tension brought about by the stress reaction. Finally, mental stress reactions may increase the psychological and physical sensitivity to pain (Westgaard, 1999). A further exploration of the plausible mechanisms is beyond the scope of this report.

10.7 GENERALISABILITY OF THE RESULTS

The following results can be generalised to the actual population studied (N = 8000 workers):-

- the cumulative incidence of musculoskeletal problems was between 11-12% over 14-16

months

- in general, individual demographics, trait, attitude or well-being factors did not independently increase the likelihood of reporting self-reported musculoskeletal complaints
- individual stress reactions, for example depression and psychosomatic symptoms may act independently to increase the likelihood of developing self-reported musculoskeletal complaints
- perceived job or life stress may act as intermediate factors between high exposure to physical and psychosocial work risk factors and the reporting of self-reported musculoskeletal complaints
- high exposure to both physical and psychosocial work risk factors produced the greatest likelihood of reporting new episodes of musculoskeletal complaints.

10.8 IMPLICATIONS OF THE RESEARCH FOR INDUSTRY

Exposure to physical work risk factors should be minimised. Exposure to psychosocial work risk factors should also be minimised, especially when workers are highly exposed to physical work risk factors.

Workers experiencing stress reactions may be more susceptible to developing musculoskeletal problems. These workers are likely to be at risk even when exposure to physical and psychosocial work risk factors has been reduced. This may mask the positive effects of the intervention.

The findings of the study has implications for the prevention and management of musculoskeletal disorders. Greater emphasis should be placed on reducing exposure in the workplace to both physical and psychosocial work risk factors. Individual stress reactions should also be monitored as part of a mental wellness programme to monitor individuals who may be at risk. A duty of care should be applied to individual workers as opposed to a group of workers.

10.9 FURTHER WORK NEEDED

Further refinement and validation of methods for monitoring work-related stress, musculoskeletal symptoms, physical and psychosocial workplace factors is needed. These methods must be applicable to a number of occupational settings and must be easy to use by practitioners, occupational health staff etc.

Interventions aimed at the organisational level are needed in order to reduce the effect of physical and psychosocial work risk factors. Health surveillance measures are needed to monitor individual reactivity so that the risk can be minimised. The results of this strategy should be evaluated.

More research is needed into the mechanisms linking stress reactions and musculoskeletal problems.

11 REFERENCES

1. Ariëns, G. A. M., Bongers, P. M., Hoogendoorn, W. E., Houtman, I. L. D., van der Wal, G., & Van Mechelen, W. (2001a), High quantitative job demands and low coworker support as risk factors for neck pain, *Spine*, **26**, 1896-1903

2. Ariëns, G. A. M., Mechelen, W. v., Bongers, P. M., Bouter, L. M., & Wal, G. v. (2001b), Psychosocial risk factors for neck pain:a systematic review, *American Journal of Industrial Medicine*, **39**, 180-194

3. Armstrong, B. K., White, E., & Saracci, S. (1994), *Principles of Exposure Assessment in Epidemiology* (Oxford University Press, Oxford)

4. Bergman, T. F., Petersen, D. H., & Lawrence, D. J. (1993), *Chiropractic Technique* (Churchill Livingston, London)

5. Bildt Thorbjörnsson, C. O., Alfredsson, L., Fredriksson, K., Köster, M., Michélsen, H., Vingård, E., Torgén, M., & Kilbom, A. (1998), Psychosocial and physical risk factors associated with low back pain: a 24 year follow up among women and men in a broad range of occupations, *Occupational and Environmental Medicine*, 84-90

6. Bongers, P. M., Kremer, A. M., & ter Laak, J. (2002), Are psychosocial factors risk factors for symptoms and signs of the shoulder, elbow or hand/wrist?:A review of the epidemiological literature, *American Journal of Industrial Medicine*, **41**, 315-342

7. Bovenzi, M. (1998), Exposure-response relationship in the hand-arm vibration syndrome: an overview of current epidemiology research, *International Archives of Occupational and Environmental Health*, **71**, 509-519

8. Buckle, P. & Devereux, J. (1999), *Work-related neck and upper limb musculoskeletal disorders* (European Agency for Safety and Health at Work, Bilbao, Spain)

9. Burdorf, A. & Sorock, G. S. (1997), Positive and negative evidence of risk factors for back disorders, *Scandinavian Journal of Work Environment and Health*, **23**, 243-256

10. Carayon, P., Smith, M. J., & Haims, M. C. (1999), Work organisation, job stress and work-related musculoskeletal disorders, *Human Factors*, **41**, 644-663

11. Cohen, S. & Williamson, G. M. (1988). Perceived stress in a probability sample of the United States. In S.Spacapan & S.Oskamp (Eds.), *The social psychology of health* (pp. 31-67), London: Sage.

12. Cox T., Griffiths, A., and Rial-González, E. (2000), Research on work-related stress. European Agency for Safety and Health at Work, Bilbao

13. Daniels K., Harris, C., and Briner, R. B. (2002), Understanding the risks of stress:A

cognitive approach. Research Report 024. HSE Books, Sudbury

14. Davis, K. G. & Heaney, C. A. (2000), The relationship between psychosocial work characteristics and low back pain: underlying methodological issues, *Clinical Biomechanics*, **15**, 389-406

15. Devereux J. J. (1997). A study of interactions between work risk factors and work related musculoskeletal disorders. Ph.D. Thesis. University of Surrey.

16. Devereux, J. J., Buckle, P. W., & Vlachonikolis, I. G. (1999), Interactions between physical and psychosocial work risk factors increase the risk of back disorders: An epidemiological study, *Occupational and Environmental Medicine*, **56**, 343-353

17. Devereux, J. J., Vlachonikolis, I. G., & Buckle, P. W. (2002), Epidemiological study to investigate potential interaction between physical and psychosocial factors at work that may increase the risk of symptoms of musculoskeletal disorder of the neck and upper limb, *Occupational and Environmental Medicine*, **59**, 269-277

18. Eysenck, H. J. & Eysenck, M. (1985), *Personality and individual differences* (Plenum, London)

19. Fairbank, J. C. T., Couper, J., Davies, J. B., & O'Brien, J. P. (1980), The Oswestry low back pain disability questionnaire, *Physiotherapy*, **66**, 271-273

20. Ferguson, S. A. & Marras, W. (1997), A literature review of low back disorder surveillance measures and risk factors, *Clinical Biomechanics*, **12**, 211-226

21. Feveile, H., Jensen, C., & Burr, H. (2002), Risk factors for neck-shoulder and wrist-hand symptoms in a 5 year follow up study of 3,990 employees in Denmark, *International Archives in Occupational and Environmental Health*, **75**, 243-251

22. Feyer, A. M., Herbison, P., Williamson, A. M., de Silva, I., Mandryk, J., Hendrie, L., & Hely, M. C. G. (2000), The role of physical and psychological factors in occupational low back pain: a prospective cohort study, *Occupational and Environmental Medicine*, **57**, 116-120

23. Fleiss, J. L. (1986), *The Measurement Of Interrater Agreement: Statistical Methods For Rates And Proportions* (John Wiley & Sons, Inc, New York)

24. Franzblau, A., Salerno, D. F., Armstrong, T. J., & Werner, R. A. (1997), Test-retest reliability of an upper-extremity discomfort questionnaire in an industrial population, *Scandinavian Journal of Work Environment and Health*, **23**, 299-307

25. Fredriksson, K., Alfredsson, L., Thorbjörnsson, C., Punnett, L., Toomingas, A., Torgén, M., & Kilbom, Å. (2000), Risk factors for neck and shoulder disorders: a nested case-control study covering a 24-year period, *American Journal of Industrial Medicine*, **38**, 516-528

26. Furnham, A. (1988), *Lay theories:Everyday understanding of problems in the social sciences* (Pergamon Press, Oxford)

27. Furnham, A. (1997), Lay theories of work stress, *Work and Stress*, **11**, 68-78

28. Goldberg D. P. and Williams, P. (1988), A user's guide to the General Health Questionnaire. NFER-Nelson, Windsor

29. Hallqvist, J., Ahlbom, A., Diderichsen, F., & Reuterwall, C. (1996), How to evaluate interaction between causes: A review of practices in cardiovascular epidemiology, *Journal of Internal Medicine*, **239**, 177-382

30. Hanson M. A., Donnan, P. T., Graveling, R. A., Maclaren, W. M., Butler, D. O., Butler, M. P., Hurley, J. F., Kidd, M. W., Lancaster, R. J., Prescott, G., Souter, C. A., Symes, A. M., and Tesh, K. M. (1999), Epidemiological and ergonomic study of occupational factors associated with symptoms of upper limb disorders in keyboard operators. Edinburgh, Institute of Occupational Medicine

31. Harkness, E. F., Macfarlane, G., Nahit, E. S., Silman, A. J., & McBeth, J. (2003), Risk factors for new onset low back pain amongst cohorts of newly employed workers, *Rhematology*, **42**,

32. Health and Safety Commission (2003), Health and Safety Statistics Highlights 2001/2002. HSE Books, Sudbury

33. Health and Safety Executive (2002), Upper limb disorders in the workplace. HSE Books, Sudbury

34. Hoogendoorn, W. E., Bongers, P. M., Vet, H. C. W. d., Houtman, I. L. D., Ariëns, G. A. M., Mechelen, W. v., & Bouter, L. M. (2002), Psychosocial work characteristics and psychological strain in relation to low back pain:results of a prospective cohort study, *Scandinavian Journal of Work, Environment and Health*, **27**, 258-267

35. Hoogendoorn, W. E., van Poppel, M., Bongers, P. M., Koes, B. W., & Bouter, L. M. (2000), Systematic review of psyshosocial factors at work and private life as risk factors for back pain, *Spine*, **25**, 2114-2125

36. Hoozemans, M. J. M., Van der Beek, A. J., Frings-Dresen, M. H. W., Van Dijk, F. J. H., & van der Woude, L. (1998), Pushing and pulling in relation to musculoskeletal disorders: a review, *Ergonomics*, **41**, 757-781

37. Houtman, I. L. D., Bongers, P. M., Smulders, P. G. W., & Kompier, M. A. J. (1994), Psychosocial stressors at work and musculoskeletal problems, *Scandinavian Journal of Work Environment and Health*, **20**, 139-145

38. Hudak, P. L., Amadio, P. C., & Bombardier, C. (1996), Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand [correction of head]). The Upper Extremity Collaborative Group (UECG) ., *American*

Journal of Industrial Medicine, **29**, 602-608

39. Hurrell, J. J. J. & McLaney, M. (1988), Exposure to job stress-a new psychometric instrument, *Scandinavian Journal of Work Environment and Health*, **14 Supplement 1**, 27-28

40. Jones, F. & Bright, J. (2001), *Stress: myth, theory and research* (Prentice Hall, Harlow)

41. Kerr, M. S., Frank, J. W., Shannon, H. S., Norman, R. W., Wells, R. P., Neumann, W. P., & et al. (2001), Biomechanical and psychological risk factors for low back pain at work, *American Journal of Public Health*, **91**, 1069-1075

42. Kleinbaum, D. G., Kupper, L. L., & Morgenstern, H. (1982), *Epidemiologic research: principles and quantitative methods* (Van Nostrand Reinhold Publishers, New York)

43. Krause, N., Ragland, D. R., Fisher, J. M., & Syme, S. L. (1998), Psychosocial job factors, physical workload and incidence of work-related spinal injury: a 5 year prospective study of urban transit operators, *Spine*, **23**, 2507-2516

44. Leclerc, A., Niedhammer, I., Landre, M.-F., Ozguler, A., Etore, P., & Pietri-Taleb, F. (1999), One-year predictive factors for various aspects of neck disorders, *Spine*, **24**, 1455-1462

45. Leino, P. (1989), Symptoms of stress predict musculoskeletal disorders, *Journal of Epidemiology and Community Health*, **43**, 293-300

46. Leino, P. & Magni, G. (1993), Depressive and distress symptoms as predictors of low back pain, neck-shoulder pain, and other musculoskeletal morbidity: *A 10 year follow-up of metal industry employees*, *Pain*, **53**, 89-94

47. Li G. and Buckle, P. (1999), Evaluating change in exposure to risk for musculoskeletal disorders a practical tool. HSE Contract Report 251/1999.

48. Liira, J. P., Shannon, H. S., Chambers, L. W., & Haines, T. A. (1996), Long term back problems and physical work exposures in the 1990 Ontario health survey, *American Journal of Public Health*, **86**, 382-387

49. Lundberg, U. (2002), Psychophysiology of work:stress, gender endocrine response and work-related upper extremity disorders, *American Journal of Industrial Medicine*, **41**, 383-392

50. MacDonald, L. A., Karasek, R. A., Punnett, L., & Scharf, T. (2001), Covariation between wokplace physical and psychosocial stressors:evidence and implications for occupational health research and prevention, *Ergonomics*, **44**, 696-718

51. Macfarlane, G. J., Hunt, I. M., & Silman, A. (2000), Role of mechanical and psychosocial factors in the onset of forearm pain:prospective population based study,

British Medical Journal, **321**, 676-686

52. Manninen, P., Riihimäki, H., & Heliövaara, M. (1995), Incidence and risk factors of low-back pain in middle-aged farmers, *Occupational Medicine Oxford*, **45**, 141-146

53. Marras, W. S., Davis, K. G., Heaney, C. A., Maronitis, A. B., & Allread, W. G. (2000), The influence of psychosocial stress, gender and personality on mechanical loading of the lumbar spine, *Spine*, **25**, 3045-3054

54. Miranda, H., Viikari-Juntura, E., Martikainen, R., Takala, E.-P., & Riihimäki, H. (2001), A prospective study of work related factors and physical exercise as predictors of shoulder pain, *Occupational and Environmental Medicine*, **58**, 528-534

55. National Research Council and Institute of Medicine (2001), Musculoskeletal disorders and the workplace: Low back and upper extremities. National Academy Press, Washington D.C.

56. NIOSH (1997), B. P. Bernard, *Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back* (DHHS (NIOSH) Publication No. 97-141, Cincinnati)

57. Op De Beeck, R. & Hermans, V. (2000), *Research on work-related low back disorders* (European Agency for Safety and Health at Work, Bilbao, Spain)

58. Palmer, K., Walker-Bone, K., Linaker, C., Reading, I., Kellingray, S., Coggon, D., & Cooper, C. (2000), The Southampton examination schedule for the diagnosis of musucloskeletal disorders of the upper limb, *Annals of the Rheumatic Diseases*, **59**, 5-11

59. Pavot, W. & Diener.E. (1993), Review of the satisfaction with life scale, *Psychological Assessment*, **5**, 164-172

60. Pietri-Taleb, F., Riihimäki, H., Viikari-Juntura, E., & Lindstrom, K. (1994), Longitudinal study on the role of personality characteristics and psychological distress in neck trouble among working men, *Pain*, **58**, 261-267

61. Pietri-Taleb, F., Riihimäki, H., Viikari-Juntura, E., Lindström, K., & Moneta, G. (1995), The role of psychological distress and personality in the incidence of sciatic pain among working men, *American Journal of Public Health*, **85**, 541-545

62. Power, C., Frank, J., Hertzman, C., Schierhout, G. H., & Li, L. (2001), Predictors of low back pain onset in a prospective British Study, *American Journal of Public Health*, **91**, 1671-1678

63. Punnett, L. & Bergqvist, U. (1997), *Visual Display Unit Work and Upper extremity musculoskeletal disorders. a review of epidemiological findings* (Swedish Institute of

Working Life, Stockholm)

64. Punnett, L., Fine, L. J., Keyserling, W. M., Herrin, G. D., & Chaffin, D. B. (1991), Back disorders and nonneutral trunk postures of automobile assembly workers, *Scandinavian Journal of Work Environment and Health*, **17**, 337-346

65. Radloff, L. S. (1977), The CES-D scale: a new self-report depression scale for research in the general population, *Applied Psychological Measurement*, **1**, 385-401

66. Rick J., Thomson, L., Briner, R. B., O'Regan, S., and Daniels, K. (2002), Review of existing supporting scientific knowledge to underpin standards of good practice for key work-related stressors-Phase I. Contract Research Report 427/2002. HSE Books, Sudbury

67. Roger, D. & Najarian, B. (1998), The relationship between emotional rumination and cortisol secretion under stress, *Personality and Individual Differences*, **24**, 531-534

68. Rydstedt, L., Devereux, J. J., & Furnham, A. (2003), Causes and alleviation of work stress: Lay theories in the British Workforce, *Work and Stress*, **Under Submission**,

69. Siegrist, J. (1996), Adverse health effects of high-effort/low-reward conditions, *Journal of Occupational Health Psychology*, **1**, 27-41

70. Smith A., Johal, S., Wadsworth, E., Smith, G. D., and Peters, T. (2000), The scale of occupational stress: the Bristol stress and health at work study. Contract Research Report 265/2000. HSE Books, Sudbury

71. Stansfeld S. A., Head, J., and Marmot, M. (2000), Work-related factors and ill health. Contract Research Report 266/2000. HSE Books, Sudbury

72. Susser, M. (1991), What is a cause and how do we know one?: A grammar for pragmatic epidemiology, *American Journal of Epidemiology*, **133**, 635-648

73. Tanaka, S., Wild, D. K., Cameron, L. L., & Freund, E. (1997), Association of occupational and non-occupational risk factors with the prevalence of self-reported carpal tunnel syndrome in a national survey of the working population, *American Journal of Industrial Medicine*, **32**, 550-556

74. Tubach, F., Leclerc, A., Landre, M.-F., & Pietri-Taleb, F. (2002), Risk factors for sick leave due to low back pain:A prospective study, *Journal of Occupational and Environmental Medicine*, **44**, 451-458

75. Verbeek, J. H. A. M. & Verbeek, A. J. (1999), Psychosocial factors at work and back pain:a prospective study in office workers, *International Journal of Occupational and Environmental Health*, **12**, 29-39

76. Warren, N., Dillon, C., Morse, T., Hall, C., & Warren, A. (2000), Biomechanical, psychosocial and organizational risk factors for WRMSD: population-based estimates

from the Connecticut Upper-Extremity Surveillance Project (CUSP), *Journal of Occupational Health Psychology*, **5**, 164-181

77. Watson, D., Clark, L. A., & Tellegren, A. (1988), Development and validation of brief measures of positive and negative effect: The PANAS scale, *Journal of Personality and Social Psychology*, **54**, 1063-1070

78. Westgaard, R. H. (1999), Effects of physical and mental stressors on muscle pain, *Scandinavian Journal of Work Environment and Health*, **25**, 19-24

79. Wiktorin, C., Karlqvist, L., & Winkel, J. (1993), Validity of self-reported exposures to work postures and manual materials handling, *Scandinavian Journal of Work Environment and Health*, **19**, 208-214

APPENDIX 1

Table 1 Odds ratios and 95% confidence interval for perceived job stress by psychosocial work factors reported at baseline

Factor	*Job stress (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2708*	*Adjusted OR with no missing data (95% CI) N=2708*
Job demands					
- low exposure	3.9	1187	1.00	1.00	1.00
- high exposure	17.1	1875	5.12 (3.73-7.04)	5.04 (3.58-7.10)	1.89 (1.28-2.80)
Decision latitude					
- low exposure	10.0	2240	1.00	1.00	1.00
- high exposure	18.0	743	1.99 (1.58-2.51)	1.87 (1.46-2.41)	1.37 (1.00-1.88)
Social Support					
- low exposure	7.1	1573	1.00	1.00	1.00
- high exposure	17.3	1506	2.75 (2.17-3.48)	2.64 (2.05-3.40)	1.23 (0.91-1.67)
Extrinsic effort					
- low exposure	3.7	1630	1.00	1.00	1.00
- high exposure	22.1	1389	7.30 (5.49-9.71)	7.45 (5.46-10.17)	3.45 (2.43-4.88)
Intrinsic effort					
- low exposure	4.1	1747	1.00	1.00	1.00
- high exposure	22.6	1325	6.81 (5.21-8.91)	6.86 (5.12-9.18)	3.34 (2.44-4.59)
Reward					
- low exposure	8.7	2398	1.00	1.00	1.00
- high exposure	24.9	595	3.47(2.75-4.38)	3.17 (2.47-4.06)	1.34 (0.98-1.85)
Role ambiguity					
- low exposure	8.6	1505	1.00	1.00	1.00
- high exposure	15.4	1541	1.93 (1.54-2.42)	1.88 (1.48-2.40)	1.35 (1.00-1.81)
Role conflict					
- low exposure	5.1	1541	1.00	1.00	1.00
- high exposure	18.9	1514	4.37 (3.36-5.68)	4.64 (3.49-6.18)	1.81 (1.31-2.49)
Job future ambiguity					
- low exposure	9.3	1791	1.00	1.00	1.00
- high exposure	16.0	1276	1.85 (1.49-2.30)	1.84 (1.45-2.33)	1.18 (0.89-1.56)
Verbal abuse					
- low exposure	10.2	2645	1.00	1.00	1.00
- high exposure	23.5	439	2.71 (2.10-3.49)	2.68 (2.03-3.55)	1.56 (1.13-2.16)
Threat of harm/injury					
- low exposure	10.9	2827	1.00	1.00	1.00
- high exposure	25.6	266	2.82 (2.09-3.81)	2.79 (2.00-3.89)	1.99 (1.33-2.97)

Table 2 Odds ratios and 95% confidence interval for perceived job stress by work organisation factors reported at baseline

Factor	*Job stress (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=3038*	*Adjusted OR with no missing data (95% CI) N=3038*
Hours worked					
- up to 41 hours/wk	9.1	2028	1.00	1.00	1.00
- 42+ hours/wk	17.7	1040	2.15 (1.73-2.68)	2.16 (1.72-2.70)	2.23 (1.76-2.83)
Type of hours					
- flexible	11.0	1251	1.00	-	-
- fixed	12.7	1813	1.17 (0.94-1.47)	-	-
Travel time to work					
- Up to 37 minutes	11.5	2209	1.00	-	-
- Over 37 minutes	13.6	806	1.22 (0.96-1.55)	-	-
Shiftwork					
- dayshift only	11.0	2265	1.00	1.00	1.00
- late or night shift	15.0	789	1.42(1.12-1.79)	1.40 (1.10-1.77)	1.32 (1.04-1.69)

Table 3 Odds ratios and 95% confidence interval for perceived job stress by significant physical work factors reported at baseline

Factor	*Job stress (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2800*	*Adjusted OR with no missing data (95% CI) N=2800*
Lifting 6-15 kg greater than 10 times/hr or lifting >16kg at all					
- low exposure	11.1	2129	1.00	1.00	1.00
- high exposure	14.2	972	1.32 (1.06-1.65)	1.35 (1.07-1.70)	0.85 (0.63-1.13)
Sitting and experiencing vibration more than half the time					
- low exposure	11.8	2650	1.00	1.00	1.00
- high exposure	16.1	322	1.44 (1.05-1.99)	1.51 (1.09-2.09)	1.13 (0.79-1.64)
Always working with the back in an awkward position					
- low exposure	9.7	2269	1.00	1.00	1.00
- high exposure	19.8	716	2.30 (1.83-2.90)	2.32 (1.83-2.94)	2.18 (1.66-2.86)
Standing in one position for 30 minutes or more without a break					
- low exposure	11.4	2626	1.00	1.00	1.00
- high exposure	16.0	450	1.48 (1.12-1.95)	1.51 (1.14-2.02)	1.21(0.88-1.65)
Vibration from a power tool or machine that made the hands vibrate during the past week					
- low exposure	11.7	2864	1.00	1.00	1.00
- high exposure	17.7	209	1.62 (1.12-2.36)	1.66 (1.13-2.42)	1.25 (0.83-1.89)
Repetitive movements of the wrists for much of the normal working day					
- low exposure	10.3	1162	1.00	1.00	1.00
- high exposure	13.2	1885	1.33 (1.05-1.67)	1.26 (0.99-1.60)	1.04 (0.80-1.35)
Repeated arm movements					
- low exposure	11.0	2333	1.00	1.00	1.00
- high exposure	15.4	680	1.48 (1.15-1.89)	1.50 (1.16-1.92)	1.14 (0.85-1.52)
Working with the head/neck bent or twisted excessively					
- low exposure	11.5	2773	1.00	1.00	1.00
- high exposure	20.3	237	1.96 (1.40-2.75)	1.99 (1.40-2.83)	1.45 (0.99-2.13)

Table 4 Odds ratios and 95% confidence interval for perceived job stress by age, gender, neuroticism and rumination reported at baseline

Factor	*Job stress (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2869*	*Adjusted OR with no missing data (95% CI) N=2869*
Age					
- up to 40 years	10.5	1410	1.00	1.00	1.00
- over 40 years	13.4	1692	1.32 (1.05-1.64)	1.36 (1.08-1.71)	1.50 (1.19-1.92)
Gender					
- male	12.5	1923	1.00	1.00	1.00
- female	11.5	1183	0.91 (0.73-1.13)	0.93 (0.74-1.17)	0.78 (0.61-1.00)
Neuroticism					
- Low score	6.5	1429	1.00	1.00	1.00
- High score	17.2	1623	2.98 (2.33-3.82)	2.99 (2.32-3.87)	2.20 (1.66-2.92)
Rumination					
- Low score	9.5	2480	1.00	1.00	1.00
- High score	25.7	483	3.30 (2.58-4.21)	3.09 (2.40-3.97)	2.18 (1.65-2.87)

Table 5 Odds ratios and 95% confidence interval for perceived job stress by non-significant lay beliefs about the causes of stress reported at baseline

Factor ***Disagree OR 1.00, Strongly agree that:***	***Crude OR*** ***(95% CI)***
Stress at work mainly affects people who have to travel frequently or long distances	1.13 (0.89-1.45)
A person is stressed mainly because he/she isn't satisfied by his/her job	1.01 (0.81-1.26)
Stress affects people whose ideas conflict with those of the company	0.83 (0.67-1.03)
Stress only affects people who aren't their own boss i.e. have to take orders from others	1.19 (0.85-1.67)
If an organisation has many young employees, older ones tend to feel threatened by this, which leads to stress	1.19 (0.95-1.50)
Women are more stressed than men at work because their careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotions	1.23 (0.97-1.57)
It is less stressful to be checked upon regularly at work, because this avoids possible mistakes and it is helpful in pointing out expectations	1.18 (0.93-1.49)
A woman will be more stressed at work because male attitudes towards female 'bosses' or colleagues create a difficult and constantly challenging climate	1.14 (0.89-1.48)
People whose work involves physical danger, like policemen, are often very stressed	1.25 (0.99-1.57)
A female employee will be stressed if her boss is too friendly	0.86 (0.69-1.07)
The risk of redundancy is a very stressful factor	0.81 (0.59-1.11)
The higher the status of the job, the more extensive and disruptive the stress people experience	1.10 (0.88-1.36)
If you work with potentially dangerous machines, all you need to do is to be careful and work properly in order not to be greatly stressed	0.84 (0.66-1.07)
If a boss is very authoritative, then the job's demands are clearly defined and employees won't become stressed	1.20 (0.91-1.60)

Table 6 Odds ratios and 95% confidence interval for perceived job stress by significant lay beliefs about the causes of stress reported at baseline

Factor	*Job stress (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2869*	*Adjusted OR with no missing data (95% CI) N=2869*
Stress mainly affects people who have an unsympathetic boss					
Disagree	10.8	1526	1.00	1.00	1.00
Strongly agree	13.3	1560	1.26 (1.02-1.57)	1.26 (1.01-1.56)	1.29 (1.01-1.67)
People who aren't busy or challenged by their work cannot really experience stress					
Disagree	11.3	2451	1.00	1.00	1.00
Strongly agree	14.9	632	1.37 (1.06-1.76)	1.37 (1.06-1.78)	1.21 (0.91-1.62)
People who have just had a promotion can't really be stressed					
Disagree	11.7	2821	1.00	1.00	1.00
Strongly agree	16.2	266	1.46 (1.03-2.06)	1.46 (1.01-2.10)	1.20 (0.78-1.86)
People who work for others, or who have to consult colleagues are more stressed because they must constantly follow other people's decisions, routines and ways of working					
Disagree	10.4	2333	1.00	1.00	1.00
Strongly agree	17.3	753	1.80 (1.43-2.26)	1.80 (1.41-2.29)	1.61 (1.23-2.10)
Men in their 40s/50s can't be stressed because most have already developed their careers and have stable positions					
Disagree	11.6	2861	1.00	1.00	1.00
Strongly agree	18.1	226	1.69 (1.19-2.42)	1.66 (1.14-2.42)	1.35 (0.86-2.11)
Stress is the result of having to work too fast and in limited amounts of time					
Disagree	9.10	964	1	1	1
Strongly agree	13.5	2131	1.55 (1.20-1.99)	1.57 (1.20-2.04)	1.44 (1.08-1.90)
If you enjoy your job, you can't really be stressed by it					
Disagree	12.8	2256	1.00	1.00	1.00
Strongly agree	10.2	826	0.77 (0.60-1.00)	0.79 (0.61-1.04)	0.76 (0.57-1.02)
A person is stressed at work usually because he/she has no friends					
Disagree	12.9	2434	1.00	1.00	1.00
Strongly agree	9.2	652	0.69 (0.51-0.92)	0.70 (0.52-0.95)	0.60 (0.43-0.83)

Table 7 Odds ratios and 95% confidence interval for perceived job stress by non-significant lay beliefs about the alleviation of stress reported at baseline

Factor ***Disagree 1.00, Strongly agree that:***	***Crude OR*** ***(95% CI)***
Reducing stress depends on how hard a person tries	0.84 (0.64-1.10)
Reducing stress depends on how much self-control the person has	0.85 (0.69-1.06)
Reducing stress depends on how embarrassed the person feels about having the problem	0.85 (0.68-1.60)
Reducing stress depends on whether there is something wrong with the person's brain or nervous system	1.02 (0.74-1.40)
Reducing stress depends on whether the person believes it is possible to eliminate the problem	0.88 (0.71-1.10)
Reducing stress depends on whether the person seeks out trained medical/psychological help	0.98 (0.78-1.23)
Reducing stress depends on how much information a person has about the problem	0.90 (0.72-1.12)
Reducing stress depends on whether the problem is a symptom of some other deep-rooted problem	0.87 (0.70-1.09)
Reducing stress depends on how lucky a person is	1.17 (0.79-1.71)
Reducing stress depends on how damaging the problem is to the person's feeling of self-worth and self-esteem	0.97 (0.78-1.22)
Reducing stress depends on how much eliminating the problem would please others	1.24 (0.96-1.61)
Reducing stress depends on how much a person stays away from a situation that makes the problem worse	1.10 (0.88-1.37)

APPENDIX 2

Table 1 Odds ratios and 95% confidence interval for self-reported low-back complaints by psychosocial work factors reported at baseline

Factor	*BP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2676*	*Adjusted OR with no missing data (95% CI) N=2676*
Job demands					
- low exposure	24.9	1166	1.00	1.00	1.00
- high exposure	31.1	1826	1.36 (1.15-1.61)	1.31 (1.10-1.57)	0.97 (0.79-1.19)
Decision latitude					
- low exposure	27.3	2200	1.00	1.00	1.00
- high exposure	32.5	717	1.28 (1.07-1.54)	1.28 (1.06-1.55)	1.07 (0.86-1.33)
Social Support					
- low exposure	25.2	1542	1.00	1.00	1.00
- high exposure	32.2	1465	1.40 (1.20-1.65)	1.42 (1.20-1.68)	1.11 (0.92-1.35)
Extrinsic effort					
- low exposure	24.6	1588	1.00	1.00	1.00
- high exposure	33.9	1362	1.57 (1.34-1.84)	1.61 (1.36-1.91)	1.31 (1.07-1.60)
Intrinsic effort					
- low exposure	24.5	1705	1.00	1.00	1.00
- high exposure	34.4	1293	1.62 (1.38-1.90)	1.63 (1.38-1.93)	1.33 (1.10-1.61)
Reward					
- low exposure	26.6	2349	1.00	1.00	1.00
- high exposure	37.2	581	1.64 (1.35-1.98)	1.55 (1.27-1.90)	1.10 (0.87-1.40)
Role ambiguity					
- low exposure	27.9	1477	1.00	1.00	1.00
- high exposure	29.6	1499	1.09 (0.93-1.28)	-	-
Role conflict					
- low exposure	23.9	1509	1.00	1.00	1.00
- high exposure	33.7	1477	1.62 (1.38-1.90)	1.61 (1.35-1.90)	1.22 (1.01-1.48)
Job future ambiguity					
- low exposure	26.4	1758	1.00	1.00	1.00
- high exposure	32.4	1238	1.34 (1.14-1.57)	1.34 (1.13-1.58)	1.18 (0.98-1.42)
Verbal abuse					
- low exposure	27.5	2585	1.00	1.00	1.00
- high exposure	36.5	427	1.51 (1.22-1.88)	1.49 (1.18-1.88)	1.17 (0.91-1.49)
Threat of harm/injury					
- low exposure	27.3	2765	1.00	1.00	1.00
- high exposure	44.5	256	2.13 (1.65-2.77)	2.00 (1.50-2.66)	1.68 (1.24-2.26)

Table 2 Odds ratios and 95% confidence interval for self-reported low-back complaints by work organisation factors reported at baseline

Factor	*BP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2970*	*Adjusted OR with no missing data (95% CI) N= 2970*
Hours worked					
- up to 41 hours/wk	27.2	1982	1.00	1.00	1.00
- 42+ hours/wk	31.3	1018	1.22 (1.03-1.44)	1.22 (1.04-1.44)	1.19 (1.01-1.41)
Type of hours					
- flexible	28.1	1221	1.00	-	-
- fixed	29.1	1773	(0.89-1.24)	-	-
Travel time to work					
- Up to 37 minutes	28.7	2159	1.00	-	-
- Over 37 minutes	28.1	789	0.97 (0.81-1.17)	-	-
Shiftwork					
- dayshift only	27.4	2221	1.00	1.00	1.00
- late or night shift	32.2	764	1.26 (1.05-1.50)	1.26 (1.06-1.51)	1.23 (1.03-1.48)

Table 3 Odds ratios and 95% confidence interval for self-reported low-back complaints by significant physical work factors reported at baseline

Factor	*BP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2890*	*Adjusted OR with no missing data (95% CI) N= 2890*
Lifting 6-15 kg greater than 10 times/hr or lifting >16 kg at all and always/often working with the back in an awkward position					
- low exposure	25.7	2489	1.00	1.00	1.00
- high exposure	47.5	423	2.62 (2.12-3.23)	2.63 (2.13-3.25)	2.25 (1.76-2 .88)
Pushing and pulling objects combined with tasks requiring lifting					
- low exposure	24.8	1840	1.00	1.00	1.00
- high exposure	35.5	1078	1.67 (1.42-1.97)	1.70 (1.44-2.00)	1.23 (1.01-1.50)
Standing in one position for 30 minutes or more without a break					
- low exposure	28.1	2566	1.00	1.00	1.00
- high exposure	33.3	439	1.28 (1.03-1.59)	1.28 (1.02-1.59)	1.02 (0.81-1.29)
Vibration from a power tool or machine that made the hands vibrate during the past week					
- low exposure	28.2	2797	1.00	1.00	1.00
- high exposure	37.7	204	1.54 (1.15-2.07)	1.62 (1.20-2 .18)	1.13 (0.82-1.56)

Table 4 Odds ratios and 95% confidence interval for self-reported low-back complaints by individual factors reported at baseline

Factor	*BP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2666*	*Adjusted OR with no missing data (95% CI) N=2666*
Age					
- up to 40 years	25.9	1385	1.00	1.00	1.00
- over 40 years	31.0	1648	1.28 (1.10-1.51)	1.32 (1.12-1.57)	1.23 (1.09-1.54)
Gender					
- male	29.4	1884	1.00	1.00	1.00
- female	27.8	1153	0.93 (0.79-1.09)	0.94 (0.79-1.12)	0.96 (0.80-1.15)
Neuroticism					
- Low score	26.1	1391	1.00	1.00	1.00
- High score	31.2	1585	1.28 (1.09-1.51)	1.26 (1.06-1.49)	1.12 (0.92-1.36)
Rumination					
- Low score	27.9	2424	1.00	1.00	1.00
- High score	33.3	468	1.29 (1.04-1.59)	1.32 (1.06-1.64)	1.06 (0.83-1.37)
Negative mood					
- Low score	26.2	1514	1.00	1.00	1.00
- High score	31.6	1397	1.31 (1.11-1.54)	1.28 (1.08-1.51)	1.19 (0.98-1.44)
Positive mood					
- Low score	30.5	1500	1.00	1.00	1.00
- High score	27.2	1425	0.85 (0.73-1.00)	0.89 (0.75-1.05)	0.99 (0.82-1.19)
Life satisfaction					
- Low score	31.0	1434	1.00	1.00	1.00
- High score	26.8	1530	0.81 (0.69-0.95)	0.83 (0.70-0.98)	0.93 (0.77-1.11)
Job satisfaction					
- Low score	27.6	2605	1.00	1.00	1.00
- High score	38.8	340	1.67 (1.32-2.11)	1.55 (1.21-1.99)	1.34 (1.03-1.74)

Table 5 Odds ratios and 95% confidence interval for self-reported low-back complaints by lay beliefs reported at baseline

Factor	*BP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2666*	*Adjusted OR with no missing data (95% CI) N=2666*
A person is stressed mainly because he/she isn't satisfied by his/her job					
Disagree	26.6	1664	1.00	1.00	1.00
Strongly agree	31.6	1351	1.28 (1.09-1.50)	1.23 (1.04-1.46)	1.17 (0.99-1.39)
People who have just had a promotion can't really be stressed					
Disagree	28.0	2760	1.00	1.00	1.00
Strongly agree	37.1	256	1.51 (1.16-1.98)	1.41 (1.06-1 .89)	1.25 (0.93-1.68)
People whose work involves physical danger, like policemen, are often very stressed					
Disagree	26.0	1088	1.00	1.00	1.00
Strongly agree	30.3	1927	1.23 (1.04-1.46)	1.23 (1.03-1.47)	1.13 (0.94-1.36)
If a boss is very authoritative, then the job's demands are clearly defined and employees won't become stressed					
Disagree	28.0	2560	1.00	1.00	1.00
Strongly agree	32.8	461	1.25 (1.01-1.55)	1.21 (0.96-1.52)	1.11 (0.88-1.41)
Reducing stress depends on whether the person seeks out trained medical/psychological help					
Disagree	27.4	1965	1.00	1.00	1.00
Strongly agree	31.5	1059	1.22 (1.04-1.44)	1.15 (0.97-1.37)	1.04 (0.87-1.25)
Reducing stress depends on how much a person stays away from a situation that makes the problem worse					
Disagree	27.5	1917	1.00	1.00	1.00
Strongly agree	31.1	1095	1.19 (1.01-1.40)	1.27 (1.07-1.51)	1.21 (1.02-1.45)

APPENDIX 3

Table 1 Odds ratios and 95% confidence interval for self-reported upper back complaints by psychosocial work factors reported at baseline

Factor	***UB P (%)***	***N***	***Crude OR (95% CI)***	***Crude OR with no missing data (95% CI) N= 2617***	***Adjusted OR with no missing data (95% CI) N= 2617***
Job demands					
- low exposure	6.4	1145	1.00	1.00	1.00
- high exposure	8.8	1800	1.42 (1. 07-1.90)	1.31 (0.97-1.78)	0.93 (0.65-1.32)
Decision latitude					
- low exposure	6.5	2160	1.00	1.00	1.00
- high exposure	11.2	715	1.82 (1.36-2.43)	1.75 (1.29-2.37)	1.27 (0.89-1.80)
Social Support					
- low exposure	5.7	1521	1.00	1.00	1.00
- high exposure	10.1	1440	1.85 (1.40-2.43)	1.83 (1.36-2.47)	1.22 (0.87-1.71)
Extrinsic effort					
- low exposure	6.2	1581	1.00	1.00	1.00
- high exposure	9.8	1323	1.64 (1.24-2.15)	1.57 (1.17-2.09)	1.22 (0.87-1.72)
Intrinsic effort					
- low exposure	6.4	1685	1.00	1.00	1.00
- high exposure	10.0	1265	1.63 (1.25-2.13)	1.58 (1.18-2.11)	1.20 (0.87-1.66)
Reward					
- low exposure	6.6	2318	1.00	1.00	1.00
- high exposure	12.3	563	1.99 (1.47-2.69)	1.90 (1.38-2.61)	1.11 (0.77-1.61)
Role ambiguity					
- low exposure	6.2	1457	1.00	1.00	1.00
- high exposure	9.6	1473	1.61 (1.22-2.12)	1.75 (1.30-2.35)	1.33 (0.96-1.85)
Role conflict					
- low exposure	5.2	1493			
- high exposure	10.7	1445	2.18 (1.64-2.89)	2.35 (1.72-3.19)	1.75 (1.24-2.47)
Job future ambiguity					
- low exposure	7.4	1745	1.00		
- high exposure	8.6	1205	1.18 (0.90-1.55)	-	-
Verbal abuse					
- low exposure	7.3	2544	1.00	1.00	1.00
- high exposure	10.7	419	1.53 (1.09-2.16)	1.75 (1.22-2.52)	1.30 (0.88-1.91)
Threat of harm/injury					
- low exposure	7.4	2723	1.00	1.00	1.00
- high exposure	12.4	249	1.78 (1.19-2.67)	2.02 (1.32-3.10)	1.44 (0.91-2.27)

Table 2 Odds ratios and 95% confidence interval for self-reported upper back complaints by significant physical work factors reported at baseline

Factor	*UB P (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2597*	*Adjusted OR with no missing data (95% CI) N= 2597*
Working with the elbows normally at or above shoulder height					
- low exposure	7.5	2568	1.00	1.00	1.00
- high exposure	12.2	156	1.71 (1.03-2.82)	1.78 (1.08-2.95)	1.13 (0.66-1.95)
Working with the head/neck bent or twisted excessively					
- low exposure	7.4	2668	1.00	1.00	1.00
- high exposure	14.1	220	2.05 (1.36-3.07)	2.15 (1.40-3.30)	1.68 (1.08-2.63)
Lifting 6-15 kg greater than 10 times/hr or lifting >16 kg at all and always/often working with the back in an awkward position					
- low exposure	6.9	2459	1.00	1.00	1.00
- high exposure	13.7	410	2.14 (1.55-2.96)	2.19 (1.56-3.06)	1.92 (1.34-2.75)
Repetitive wrist movements for much of the normal working day					
- low exposure	5.8	1134	1.00	1.00	1.00
- high exposure	9.1	1795	1.63 (1.21-2.19)	1.71 (1.24-2 .35)	1.51 (1.09-2.09)

Table 3 Odds ratios and 95% confidence interval for self-reported upper back complaints by individual factors reported at baseline

Factor	*UB P (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2649*	*Adjusted OR with no missing data (95% CI) N=2649*
Age					
- up to 40 years	8.6	1358	1.00	1.00	1.00
- over 40 years	7.2	1628	0.83 (0.64-1.08)	0.92 (0.69-1.22)	0.95 (0.71-1.27)
Gender					
- male	6.7	1853	1.00	1.00	1.00
- female	9.7	1137	1.48 (1.13-1.94)	1.49 (1.12-1.99)	1.52 (1.13-2.04)
Neuroticism					
- Low score	6.0	1370	1.00	1.00	1.00
- High score	9.7	1560	1.68 (1.27-2.23)	1.71 (1.27-2.30)	1.33 (0.93-1.88)
Rumination					
- Low score	6.9	2378	1.00	1.00	1.00
- High score	12.2	469	1.86 (1.35-2.55)	1.76 (1.26-2.45)	1.19 (0.81-1.76)
Negative mood					
- Low score	6.3	1486	1.00	1.00	1.00
- High score	9.2	1383	1.50 (1.14-1.98)	1.52 (1.4-2.02)	1.10 (0.79-1.54)
Positive mood					
- Low score	8.8	1484	1.00	1.00	1.00
- High score	6.7	1401	0.74 (0.56-0.98)	0.81 (0.61-1.08)	1.08 (0.79-1.47)
Life satisfaction					
- Low score	9.5	1416	1.00	1.00	1.00
- High score	6.3	1503	0.64 (0.49-0.84)	0.65 (0.49-0.87)	0.76 (0.55-1.05)
Job satisfaction					
- Low score	7.1	2558	1.00	1.00	1.00
- High score	14.1	341	2.15 (1.53-3.02)	1.96 (1.36-2.83)	1.68 (1.14-2.47)

Table 4 Odds ratios and 95% confidence interval for self-reported upper back complaints by lay beliefs reported at baseline

Factor	*HWP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2649*	*Adjusted OR with no missing data (95% CI) N=2649*
The person is stressed at work usually because he/she has no friends					
Disagree	7.3	2344	1.00	1.00	1.00
Strongly agree	10.1	624	1.42 (1.05-1.92)	1.35 (0.97-1.87)	1.26 (0.88-1.79)
Stressed mainly affects people who have an unsympathetic boss					
Disagree	6.9	1478	1.00	1.00	1.00
Strongly agree	8.9	1490	1.32 (1.01-1.73)	1.33 (0.99-1.77)	1.19 (0.87-1.62)
If an organisation has a lot of young employees, older ones tend to feel threatened by this, which leads to stress					
Disagree	7.3	2107	1.00	1.00	1.00
Strongly agree	9.4	871	1.33 (1.00-1.76)	1.31 (0.97-1.77)	1.20 (0.88-1.63)
Reducing stress depends on how embarrassed the person feels about having the problem					
Disagree	7.1	1815	1.00	1.00	1.00
Strongly agree	9.2	1156	1.33 (1.02-1.74)	1.26 (0.95-1.68)	1.23 (0.92-1.66)

APPENDIX 4

Table 1 Odds ratios and 95% confidence interval for self-reported neck complaints by psychosocial work factors reported at baseline

Factor	***NP (%)***	***N***	***Crude OR (95% CI)***	***Crude OR with no missing data (95% CI) N= 2647***	***Adjusted OR with no missing data (95% CI) N= 2647***
Job demands					
- low exposure	14.3	1122	1.00	1.00	1.00
- high exposure	19.8	1790	1.49 (1.21-1.82)	1.55 (1.25-1.92)	1.22 (0.95-1.55)
Decision latitude					
- low exposure	17.0	2145	1.00	1.00	1.00
- high exposure	18.5	697	1.11 (0.89-1.38)	-	-
Social Support					
- low exposure	14.7	1500	1.00	1.00	1.00
- high exposure	20.6	1428	1.50 (1.24-1.82)	1.48 (1.21-1.81)	1.11 (0.89-1.40)
Extrinsic effort					
- low exposure	15.5	1550	1.00	1.00	1.00
- high exposure	20.4	1321	1.40 (1.16-1.70)	1.44 (1.18-1.76)	1.03 (0.81-1.31)
Intrinsic effort					
- low exposure	13.8	1662	1.00	1.00	1.00
- high exposure	23.2	1256	1.88 (1.55-2.27)	1.79 (1.47-2.19)	1.49 (1.19-1.87)
Reward					
- low exposure	16.1	2304	1.00	1.00	1.00
- high exposure	23.9	545	1.64 (1.31-2.05)	1.63 (1.29-2.05)	1.14 (0.87-1.49)
Role ambiguity					
- low exposure	15.2	1443	1.00	1.00	1.00
- high exposure	20.4	1452	1.42 (1.18-1.73)	1.42 (1.16-1.73)	1.17 (0.94-1.47)
Role conflict					
- low exposure	14.8	1470	1.00	1.00	1.00
- high exposure	20.8	1437	1.51 (1.25-1.83)	1.58 (1.29-1.93)	1.13 (0.90-1.43)
Job future ambiguity					
- low exposure	15.6	1719	1.00	1.00	1.00
- high exposure	21.0	1200	1.44 (1.19-1.74)	1.47 (1.21-1.80)	1.25 (1.00-1.55)
Verbal abuse					
- low exposure	17.0	2519	1.00	1.00	1.00
- high exposure	22.7	410	1.44 (1.12-1.85)	1.61 (1.24-2.10)	1.33 (1.00-1.75)
Threat of harm/injury					
- low exposure	17.2	2692	1.00	1.00	1.00
- high exposure	23.2	246	1.45 (1.06-1.99)	1.61 (1.16-2.23)	1.37 (0.97-1.93)

Table 2 Odds ratios and 95% confidence interval for self-reported neck complaints by work organisation factors reported at baseline

Factor	*NP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI)*	*Adjusted OR with no missing data (95% CI)*
Hours worked					
- up to 41 hours/wk	18.2	1937	1.00	1.00	1.00
- 42+ hours/wk	16.6	982	0.89 (0.73-1.10)	-	-
Type of hours					
- flexible	18.6	1181	1.00	1.00	1.00
- fixed	17.0	1733	0.90 (0.74-1.09)	-	-
Travel time to work					
- Up to 37 minutes	17.2	2116	1.00	1.00	1.00
- Over 37 minutes	18.8	756	1.11 (0.90-1.38)	-	-
Shiftwork					
- dayshift only	18.2	2166	1.00	1.00	1.00
- late or night shift	16.1	741	0.86 (0.69-1.07)	-	-

Table 3 Odds ratios and 95% confidence interval for self-reported neck complaints by significant physical work factors reported at baseline

Factor	*NP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2691*	*Adjusted OR with no missing data (95% CI) N= 2691*
Lifting 6-15 kg greater than 10 times/hr or lifting >16 kg at all and always/often working with the back in an awkward position					
- low exposure	16.3	2426	1.00	1.00	1.00
- high exposure	25.4	406	1.75 (1.36-2.24)	1.79 (1.39-2.30)	2.24 (1.65-3.04)
Repetitive arm movements					
- low exposure	16.4	2241	1.00	1.00	1.00
- high exposure	22.4	625	1.47 (1.18-1.83)	1.45 (1.15-1.81)	1.22 (0.95-1.57)
Working with the head/neck bent or twisted excessively					
- low exposure	16.2	2638	1.00	1.00	1.00
- high exposure	37.1	221	3.06 (2.28-4.09)	3.08 (2.26-4.20)	2.81 (2.02-3.89)
Vibration from a power tool or machine that made the hands vibrate during the past week					
- low exposure	17.1	2722	1.00	1.00	1.00
- high exposure	24.9	197	1.61 (1.15-2.25)	1.69 (1.20-2.38)	1.85 (1.26-2.71)
Sitting and using a computer more than half the time					
- low exposure	15.1	1269	1.00	1.00	1.00
- high exposure	19.7	1634	1.38 (1.13-1.68)	1.37 (1.12-1.67)	1.79 (1.37-2.34)
Seated for 30 minutes or more without a break					
- low exposure	13.6	799	1.00	1.00	1.00
- high exposure	19.1	2117	1.50 (1.19-1.88)	1.50 (1.18-1.90)	1.54 (1.17-2.05)

Table 4 Odds ratios and 95% confidence interval for self-reported neck complaints by individual factors reported at baseline

Factor	*NP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2619*	*Adjusted OR with no missing data (95% CI) N=2619*
Age					
- up to 40 years	21.2	1335	1.00	1.00	1.00
- over 40 years	22.8	1590	1.10 (0.92-1.31)	1.25 (1.02-1.53)	1.38 (1.12-1.70)
Gender					
- male	18.1	1815	1.00	1.00	1.00
- female	28.5	1114	1.80 (1.51-2.15)	1.74 (1.43-2.13)	1.74 (1.41-2.16)
Neuroticism					
- Low score	17.6	1356	1.00	1.00	1.00
- High score	26.3	1519	1.67 (1.40-2.01)	1.62 (1.32-1.98)	1.25 (0.98-1.59)
Rumination					
- Low score	20.3	2330	1.00	1.00	1.00
- High score	30.9	459	1.75 (1.41-2.19)	1.65 (1.29-2.11)	1.15 (0.87-1.53)
Negative mood					
- Low score	18.0	469	1.00	1.00	1.00
- High score	26.6	1344	1.64 (1.37-1.97)	1.64 (1.34-2.01)	1.36 (1.08-1.72)
Positive mood					
- Low score	23.9	1449	1.00	1.00	1.00
- High score	20.4	1376	0.82 (0.68-0.97)	0.82 (0.68-1.01)	1.05 (0.84-1.31)
Life satisfaction					
- Low score	25.0	1384	1.00	1.00	1.00
- High score	19.5	1477	0.73 (0.61-0.87)	0.77 (0.63-0.94)	0.93 (0.75-1.17)
Job satisfaction					
- Low score	20.6	2510	1.00	1.00	1.00
- High score	33.4	332	1.93 (1.51-2.47)	1.84 (1.40-2.42)	1.63 (1.22-2.18)

Table 5 Odds ratios and 95% confidence interval for self-reported neck complaints by lay beliefs reported at baseline

Factor	*NP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2619*	*Adjusted OR with no missing data (95% CI) N=2619*
If an organisation has a lot of young employees, older ones tend to feel threatened by this, which leads to stress					
Disagree	20.9	2058	1.00	1.00	1.00
Strongly agree	24.9	859	1.26 (1.04-1.52)	1.24 (1.00-1.53)	1.29 (1.03-1.61)
Women are more stressed that men at work because their careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotions					
Disagree	21.2	2163	1.00	1.00	1.00
Strongly agree	24.7	748	1.22 (1.01-1.49)	1.09 (0.87-1.36)	0.86 (0.67-1.09)
It is less stressful to be checked upon regularly at work, because this avoids possible mistakes and it is helpful in pointing out expectations					
Disagree	23.1	2133	1.00	1.00	1.00
Strongly agree	19.6	779	0.82 (0.67-1.00)	0.74 (0.59-0.94)	0.74 (0.58-0.94)
Reducing stress depends on whether the person joins other self-help groups for their problems					
Disagree	23.1	2173	1.00	1.00	1.00
Strongly agree	19.1	738	0.79 (0.64-0.97)	0.75 (0.59-0.96)	0.78 (0.61-1.00)

APPENDIX 5

Table 1 Odds ratios and 95% confidence interval for self-reported shoulder complaints by psychosocial work factors reported at baseline

Factor	***SH P (%)***	***N***	***Crude OR (95% CI)***	***Crude OR with no missing data (95% CI) N= 2612***	***Adjusted OR with no missing data (95% CI) N= 2612***
Job demands					
- low exposure	14.0	1146			
- high exposure	18.0	1805	1.34 (1.09-1.64)	1.34 (1.08-1.68)	1.13 (0.89-1.46)
Decision latitude					
- low exposure	15.2	2173			
- high exposure	19.1	708	1.31 (1.05-1.64)	1.38 (1.10-1.75)	1.08 (0.82-1.40)
Social Support					
- low exposure	13.3	1522			
- high exposure	19.4	1442	1.57 (1.29-1.91)	1.58 (1.28-1.95)	1.24 (0.97-1.57)
Extrinsic effort					
- low exposure	14.4	1578			
- high exposure	18.5	1332	1.35 (1.11-1.64)	1.35 (1.10-1.66)	1.12 (0.87-1.44)
Intrinsic effort					
- low exposure	14.8	1692			
- high exposure	18.7	1265	1.32 (1.09-1.61)	1.36 (1.10-1.67)	1.12 (0.89-1.40)
Reward					
- low exposure	14.5	2317			
- high exposure	23.5	570	1.81 (1.44-2.26)	1.74 (1.37-2.20)	1.21 (0.91-1.60)
Role ambiguity					
- low exposure	14.8	1455			
- high exposure	18.1	1481	1.27 (1.04-1.54)	1.32 (1.07-1.63)	1.03 (0.81-1.30)
Role conflict					
- low exposure	14.2	1495			
- high exposure	18.9	1447	1.40 (1.15-1.70)	1.37 (1.11-1.70)	1.02 (0.80-1.30)
Job future ambiguity					
- low exposure	13.8	1746			
- high exposure	20.5	1210	1.61 (1.33-1.96)	1.67 (1.35-2.06)	1.45 (1.15-1.82)
Verbal abuse					
- low exposure	15.7	2549			
- high exposure	20.5	420	1.39 (1.07-1.80)	1.42 (1.07-1.89)	1.19 (0.89-1.61)
Threat of harm/injury					
- low exposure	15.9	2731			
- high exposure	22.3	247	1.52 (1.11-2.09)	1.58 (1.12-2.24)	1.34 (0.93-1.93)

Table 2 Odds ratios and 95% confidence interval for self-reported shoulder complaints by significant physical work factors reported at baseline

Factor	*UB P (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2269*	*Adjusted OR with no missing data (95% CI) N= 2269*
Working with the elbows normally at or above shoulder height					
- low exposure	15.8	2582	1.00	1.00	1.00
- high exposure	22.7	150	1.56 (1.05-2.32)	1.70 (1.13-2.56)	1.19 (0.75-1.89)
Working with the head/neck bent or twisted excessively					
- low exposure	15.5	2669	1.00	1.00	1.00
- high exposure	29.2	226	2.25 (1.66-3.05)	2.25 (1.59-3.18)	1.64 (1.13-2.37)
Lifting 6-15 kg greater than 10 times/hr or lifting >16 kg at all and always/often working with the back in an awkward position					
- low exposure	15.0	2453	1.00	1.00	1.00
- high exposure	24.3	419	1.82 (1.42-2.33)	1.93 (1.47-2.53)	1.83 (1.34-2.50)
Repetitive wrist movements for much of the normal working day					
- low exposure	11.0	1133	1.00	1.00	1.00
- high exposure	20.0	1804	2.01 (1.62-2.50)	2.04 (1.59-2.63)	1.65 (1.25-2.17)
Repetitive arm movements					
- low exposure	14.3	2258			
- high exposure	24.4	644	1.92 (1.55-2.39)	1.84 (1.44-2.35)	1.35 (1.02-1.78)
Seated for 30 minutes or more without a break					
- low exposure	12.7	809			
- high exposure	17.8	2147	1.49 (1.18-1.88)	1.29 (1.00-1.67)	1.68 (1.26-2.23)
Working with a deviated or bent wrist position					
- low exposure	13.7	1283			
- high exposure	19.3	1263	1.51 (1.22-1.86)	1.35 (1.08-1.69)	1.01 (0.79-1.30)

Table 3 Odds ratios and 95% confidence interval for self-reported shoulder complaints by individual factors reported at baseline

Factor	*UB P (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2657*	*Adjusted OR with no missing data (95% CI) N=2657*
Age					
- up to 40 years	14.9	1369			
- over 40 years	17.8	1622	1.23 (1.01-1.50)	1.31 (1.06-1.62)	1.33 (1.07-1.65)
Gender					
- male	13.7	1861			
- female	21.0	1134	1.67 (1.38-2.03)	1.64 (1.33-2.02)	1.54 (1.23-1.92)
Neuroticism					
- Low score	14.6	1381			
- High score	18.2	1554	1.31 (1.07-1.59)	1.26 (1.02-1.55)	0.89 (0.70-1.14)
Rumination					
- Low score	15.4	2382			
- High score	20.9	468	1.46 (1.14-1.87)	1.47 (1.14-1.90)	1.04 (0.78-1.40)
Negative mood					
- Low score	12.5	1488			
- High score	20.6	1384	1.82 (1.48-2.22)	1.73 (1.40-2.14)	1.61 (1.26-2.05)
Positive mood					
- Low score	17.5	1475			
- High score	15.2	1411	0.84 (0.69-1.03)	-	-
Life satisfaction					
- Low score	18.2	1416			
- High score	14.7	1506	0.77 (0.63-0 .94)	0.79 (0.64-0.97)	0.93 (0.74-1.16)
Job satisfaction					
- Low score	15.0	2563			
- High score	26.0	339	1.9 (1.52-2.59)	1.89 (1.43-2.50)	1.72 (1.28-2.31)

Table 4 Odds ratios and 95% confidence interval for self-reported shoulder complaints by lay beliefs reported at baseline

Factor	*SH P (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2657*	*Adjusted OR with no missing data (95% CI) N=2657*
Women are more stressed that men at work because their careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotions					
Disagree	14.9	2209			
Strongly agree	20.8	765	1.50 (1.22-1.85)	1.41 (1.13-1.77)	1.11 (0.86-1.44)
A woman will be more stressed at work because male attitudes towards female bosses or colleagues create a difficult and constantly challenging climate					
Disagree	15.4	2338			
Strongly agree	20.2	634	1.39 (1.11-1.73)	1.40 (1.10-1.77)	1.24 (0.96-1.62)
People whose work involves physical danger, like policeman, are often very stressed					
Disagree	14.5	1068			
Strongly agree	17.5	1904	1.25 (1.02-1.54)	1.32 (1.06-1.65)	1.24 (0.99-1.56)
Reducing stress depends on how much self-control the person has					
Disagree	17.9	1503			
Strongly agree	15.0	478	0.81 (0.67-0.99)	0.78 (0.63-0.96)	0.85 (0.69-1.06)

APPENDIX 6

Table 1 Odds ratios and 95% confidence interval for self-reported elbow/forearm complaints by psychosocial work factors reported at baseline

Factor	***ELB P (%)***	***N***	***Crude OR (95% CI)***	***Crude OR with no missing data (95% CI) N= 2699***	***Adjusted OR with no missing data (95% CI) N= 2699***
Job demands					
- low exposure	7.6	1178	1.00	1.00	1.00
- high exposure	9.6	1849	1.29 (0.99-1.68)	-	-
Decision latitude					
- low exposure	7.7	2222			
- high exposure	12.9	729	1.79 (1.37-2.33)	1.72 (1.30-2.30)	1.28 (0.93-1.78)
Social Support					
- low exposure	6.4	1567			
- high exposure	11.4	1474	1.87 (1.44-2.42)	1.88 (1.42-2.48)	1.35 (0.98-1.85)
Extrinsic effort					
- low exposure	7.4	1619			
- high exposure	10.8	1366	1.51 (1.17-1.94)	1.41 (1.08-1.85)	1.13 (0.83-1.34)
Intrinsic effort					
- low exposure	7.6	1731			
- high exposure	10.4	1302	1.41 (1.10-1.82)	1.38 (1.05-1.80)	1.08 (0.80-1.46)
Reward					
- low exposure	7.4	2371			
- high exposure	14.9	585	2.18 (1.66-2.87)	2.19 (1.64-2.93)	1.43 (1.01-2.02)
Role ambiguity					
- low exposure	7.6	1490			
- high exposure	9.7	1519	1.32 (1.02-1.70)	1.37 (1.05-1.80)	0.93 (0.68-1.26)
Role conflict					
- low exposure	6.6	1534			
- high exposure	11.0	1486	1.76 (1.36-2.28)	1.81 (1.37-2.38)	1.34 (0.98-1.83)
Job future ambiguity					
- low exposure	7.0	1779			
- high exposure	11.4	1252	1.72 (1.34-2.22)	1.63 (1.24-2.13)	1.28 (0.96-1.72)
Verbal abuse					
- low exposure	8.4	2617			
- high exposure	11.9	430	1.47 (1.07-2.04)	1.38 (0.97-1.98)	1.05 (0.72-1.54)
Threat of harm/injury					
- low exposure	8.2	2796			
- high exposure	15.4	260	2.03 (1.41-2.92)	1.81 (1.20-2.73)	1.39 (0.90-2.15)

Table 2 Odds ratios and 95% confidence interval for self-reported elbow/forearm complaints by significant physical work factors reported at baseline

Factor	*ELB P (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2472*	*Adjusted OR with no missing data (95% CI) N= 2472*
Vibration from a power tool or machine that made the hands vibrate during the past week					
- low exposure	8.1	2835			
- high exposure	18.4	201	2.54 (1.74-3.72)	2.58 (1.72-3.87)	2.08 (1.36-3.19)
Repetitive movements of the wrists for much of the normal working day					
- low exposure	7.1	1154			
- high exposure	10.1	1858	1.46 (1.12-1.92)	1.61 (1.5-2.20)	1.14 (0.81-1.61)
Repetitive arm movements					
- low exposure	7.5	2310			
- high exposure	13.9	668	1.99 (1.52-2.60)	2.22 (1.66-2.98)	1.70 (1.22-2.37)
Working with the head/neck bent or twisted excessively					
- low exposure	8.4	2743			
- high exposure	14.8	229	1.91 (1.29-2.81)	2.03 (1.33-3.09)	1.37 (0.88-2.15)
Lifting 6-15 kg greater than 10 times/hr or lifting >16 kg at all and always/often working with the back in an awkward position					
- low exposure	8.1	2510			
- high exposure	13.6	435	1.77 (1.30-2.42)	1.85 (1.33-2.58)	1.17 (0.81-1.69)
Performing work with a deviated or bent wrist position					
- low exposure	6.3	1309			
- high exposure	11.0	1305	1.84 (1.39-2.44)	1.91 (1.42-2.55)	1.47 (1.07-2.01)

Table 3 Odds ratios and 95% confidence interval for self-reported elbow/forearm complaints by individual factors reported at baseline

Factor	*ELB P (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2750*	*Adjusted OR with no missing data (95% CI) N=2750*
Age					
- up to 40 years	5.0	1408			
- over 40 years	12.0	1660	2.57 (1.94-3.40)	2.81 (2.08-3.79)	2.88 (2.12-3.91)
Gender					
- male	8.3	1902			
- female	9.7	1170	1.19 (0.93-1.53)	1.27 (0.97-1.65)	1.32 (1.00-1.75)
Neuroticism					
- Low score	7.8	1417			
- High score	9.9	1593	1.30 (1.01-1.68)	1.37 (1.05-1.79)	1.12 (0.82-1.53)
Rumination					
- Low score	8.1	2448			
- High score	12.8	476	1.66 (1.22-2.25)	1.67 (1.22-2.29)	1.22 (0.85-1.76)
Negative mood					
- Low score	7.4	1537			
- High score	10.5	1414	1.46 (1.13-1.88)	1.50 (1.15-1.96)	1.40 (1.03-1.91)
Positive mood					
- Low score	10.0	1523			
- High score	8.0	1439	0.78 (0.61-1.01)	-	-
Life satisfaction					
- Low score	9.3	1455			
- High score	8.6	1543	0.92 (0.71-1.18)	-	-
Job satisfaction					
- Low score	8.0	2635			
- High score	15.4	344	2.08 (1.51-2.88)	2.08 (1.49-2.92)	1.75 (1.23-2.49)

Table 4 Odds ratios and 95% confidence interval for self-reported elbow/forearm complaints by lay beliefs reported at baseline

Factor	*HWP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2750*	*Adjusted OR with no missing data (95% CI) N=2750*
People whose work involves physical danger, like policeman, are often very stressed					
Disagree	7.4	1099	1.00	1.00	1.00
Strongly agree	9.6	1950	1.34 (1.02-1.76)	1.30 (1.00-1.70)	1.24 (0.95-1.64)
Women are more stressed that men at work because there careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotions					
Disagree	8.4	2268	1.00	1.00	1.00
Strongly agree	10.2	783	1.25 (0.95-1.64)	1.29 (0.97-1.71)	1.05 (0.77-1.43)

APPENDIX 7

Table 1 Odds ratios and 95% confidence interval for self-reported hand/wrist complaints by psychosocial work factors reported at baseline

Factor	***HW P (%)***	***N***	***Crude OR (95% CI)***	***Crude OR with no missing data (95% CI) N= 2775***	***Adjusted OR with no missing data (95% CI) N= 2775***
Job demands					
- low exposure	16.5	183	1.00	1.00	1.00
- high exposure	18.9	1861	1.18 (0.97-1.43)	-	-
Decision latitude					
- low exposure	16.3	2236	1.00	1.00	1.00
- high exposure	22.6	731	1.50 (1.22-1.84)	1.48 (1.19-1.83)	1.10 (0.87-1.41)
Social Support					
- low exposure	15.7	1569	1.00	1.00	1.00
- high exposure	20.6	1489	1.39 (1.16-1.67)	1.42 (1.17-1.73)	1.07 (0.86-1.34)
Extrinsic effort					
- low exposure	17.0	1621	1.00	1.00	1.00
- high exposure	19.1	1380	1.15 (0.96-1.39)	-	-
Intrinsic effort					
- low exposure	16.0	1741	1.00	1.00	1.00
- high exposure	20.4	1309	1.34 (1.12-1.62)	1.37 (1.13-1.67)	1.27 (1.04-1.56)
Reward					
- low exposure	16.3	2388	1.00	1.00	1.00
- high exposure	24.2	586	1.64 (1.32-2.04)	1.66 (1.32-2.08)	1.20 (0.92-1.56)
Role ambiguity					
- low exposure	14.0	1504	1.00	1.00	1.00
- high exposure	21.9	1522	1.73 (1.43-2.09)	1.73 (1.42-2.11)	1.45 (1.16-1.82)
Role conflict					
- low exposure	17.1	1535	1.00	1.00	1.00
- high exposure	18.9	1501	1.13 (0.94-1.36)	-	-
Job future ambiguity					
- low exposure	15.4	1784	1.00	1.00	1.00
- high exposure	21.6	1262	1.52 (1.26-1.83)	1.54 (1.27-1.87)	1.25 (1.01-1.55)
Verbal abuse					
- low exposure	17.5	2632	1.00	1.00	1.00
- high exposure	20.4	431	1.21 (0.94-1.56)	-	-
Threat of harm/injury					
- low exposure	17.3	2808	1.00	1.00	1.00
- high exposure	23.9	264	1.49 (1.11-2.02)	1.45 (1.05-2.01)	1.28 (0.92-1.79)

Table 2 Odds ratios and 95% confidence interval for self-reported hand/wrist complaints by significant physical work factors reported at baseline

Factor	*HWP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2267*	*Adjusted OR with no missing data (95% CI) N= 2267*
Vibration from a power tool or machine that made the hands vibrate during the past week					
- low exposure	17.1	2847	1.00	1.00	1.00
- high exposure	29.8	205	2.06 (1.50 -2.82)	2.06 (1.41-3.02)	2.09 (1.39-3.14)
Repetitive movements of the wrists for much of the normal working day					
- low exposure	10.4	1158	1.00	1.00	1.00
- high exposure	22.7	1868	2.52 (2.03-3.13)	2.54 (1.98-3.27)	1.95 (1.48-2.57)
Repetitive arm movements					
- low exposure	15.1	2323	1.00	1.00	1.00
- high exposure	27.8	670	2.16 (1.76-2.65)	1.95 (1.53-2.48)	1.39 (1.07-1.81)
Working with the head/hand/wrist bent or twisted excessively					
- low exposure	17.2	2752	1.00	1.00	1.00
- high exposure	28.8	233	1.94 (1.44-2.62)	1.89 (1.30-2.73)	1.29 (0.87-1.89)
Using a keyboard more than four hours per day					
- low exposure	15.5	1456	1.00	1.00	1.00
- high exposure	20.4	1287	1.40 (1.15-1.70)	1.34 (1.08-1.66)	1.32 (1.04-1.68)
Performing work with a deviated or bent wrist position					
- low exposure	13.3	1308	1.00	1.00	1.00
- high exposure	22.9	1311	1.93 (1.58-2.37)	1.83 (1.47-2.28)	1.50 (1.19-1.89)

Table 3 Odds ratios and 95% confidence interval for self-reported hand/wrist complaints by individual factors reported at baseline

Factor	*HWP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N=2721*	*Adjusted OR with no missing data (95% CI) N=2721*
Age					
- up to 40 years	16.5	1408	1.00	1.00	1.00
- over 40 years	19.1	1677	1.19 (0.99-1.43)	1.17 (0.96-1.42)	1.19 (0.97-1.45)
Gender					
- male	15.9	1909	1.00	1.00	1.00
- female	21.2	1180	1.42 (1.18-1.71)	1.41 (1.16-1.72)	1.31 (1.05-1.62)
Neuroticism					
- Low score	14.0	1422	1.00	1.00	1.00
- High score	21.4	1606	1.67 (1.38-2.02)	1.70 (1.39-2.08)	1.29 (1.02-1.64)
Rumination					
- Low score	16.3	2462	1.00	1.00	1.00
- High score	26.6	477	1.86 (1.48-2.34)	1.88 (1.48-2.38)	1.27 (0.96-1.67)
Negative mood					
- Low score	14.9	1535	1.00	1.00	1.00
- High score	21.5	1425	1.56 (1.29-1.88)	1.57 (1.29-1.91)	1.19 (0.94-1.50)
Positive mood					
- Low score	19.8	1519	1.00	1.00	1.00
- High score	16.3	1455	0.79 (0.65-0.95)	0.75 (0.62-0.91)	0.95 (0.76-1.18)
Life satisfaction					
- Low score	20.4	1462	1.00	1.00	1.00
- High score	15.8	1552	0.73 (0.61-0.88)	0.76 (2.62-0.92)	0.95 (0.76-1.18)
Job satisfaction					
- Low score	16.7	2648	1.00	1.00	1.00
- High score	27.5	346	1.89 (1.46-2.45)	1.93 (1.48-2.53)	1.59 (1.20-2.11)

Table 4 Odds ratios and 95% confidence interval for self-reported hand/wrist complaints for lay beliefs reported at baseline

Factor	*HWP (%)*	*N*	*Crude OR (95% CI)*	*Crude OR with no missing data (95% CI) N= 2721*	*Adjusted OR with no missing data (95% CI) N=2721*
People who work for others, or who have to consult colleagues are more stressed because they must constantly follow other people's decisions, routines and ways of working					
Disagree	17.1	2321	1.00	1.00	1.00
Strongly agree	20.8	745	1.28 (1.04-1.57)	1.28 (1.03-1.60)	1.11 (0.87-1.40)
The person is stressed mainly because he/she isn't satisfied by his/her job					
Disagree	16.0	1700	1.00	1.00	1.00
Strongly agree	20.4	1366	1.34 (1.12-1.61)	1.44 (1.18-1.75)	1.39 (1.14-1.71)
If an organisation as a lot of young employees, older ones tend to feel threatened by this, which leads to stress					
Disagree	16.9	2184	1.00	1.00	1.00
Strongly agree	20.4	893	1.26 (1.03-1.53)	1.33 (1.08-1.64)	1.18 (0.94-1.47)
Women are more stressed that men at work because there careers develop more slowly, and they are expected to perform better than male colleagues to obtain promotions					
Disagree	16.8	2274	1.00	1.00	1.00
Strongly agree	21.4	794	1.35 (1.10-1.10)	1.37 (1.10-1.69)	1.00 (0.78-1.28)
A woman will be more stressed at work because of male attitudes towards female bosses or colleagues create a difficult and constantly challenging climate					
Disagree	16.5	2411	1.00	1.00	1.00
Strongly agree	23.4	654	1.55 (1.26-1.91)	1.61 (1.29-2.01)	1.41 (1.10-1.81)
Reducing stress depends on a person's general ability to overcome problems					
Disagree	20.1	935	1.00	1.00	1.00
Strongly agree	16.9	2138	0.81 (0.66-0.98)	0.79 (0.64-0.97)	0.85 (0.67-1.08)
Reducing stress depends on how much self-control the person has					
Disagree	19.3	1548	1.00	1.00	1.00
Strongly agree	16.4	1526	0.83 (0.69-0.99)	0.79 (0.65-0.96)	0.86 (0.68-1.09)
Reducing stress depends on how embarrassed the person feels about having the problem					
Disagree	17.9	1890	1.00	1.00	1.00
Strongly agree	17.8	1179	0.99 (0.82-1.20)	0.96 (0.78-1.17)	0.98 (0.79-1.22)

APPENDIX 8

The Questionnaire

Tables 1-5 show the factors assessed by questionnaire in the study. Many of the constructs have been used in previous epidemiological studies. A measure of reliability (Chronbach's alpha) is provided for constructs measured by a multi-item scale from the Stress/MSD study data, unless stated otherwise. The source refers to either the author of the scale or a research paper that has previously tested the psychometric properties of the scale for measuring the construct. Chronbach's alpha reported in the source is provided where possible under comments. Alphas over 0.7 indicate that the scale has good reliability for measuring the construct.

Table 1 A summary of work organisation factors measured in the baseline questionnaire

Construct	*N of items*	*Alpha*	*Source*	*Comment*
Hours worked	1	Single item	None	Measures the normal working hours per week in a job
Type of hours	1	Single item	None	Flexible versus fixed hours
Travel time to work	1	Single item	None	Duration in minutes
Shiftwork	1	Single item	None	Working a late or night shift

Table 2 A summary of psychological factors measured in the baseline questionnaire

Construct	*N of items*	*Alpha*	*Source*	*Comment*
Job demands	4	0.66	(Stansfeld et al., 2000)	Working very fast, intensively, enough time to do everything and difficulty combining tasks
Decision latitude	15	0.88	(Stansfeld et al., 2000)	Control over work speed, breaks, decisions, environment and work, qualitative demands, learning new things, and task variation etc
Extrinsic Effort	5	0.86	(Siegrist, 1996)	Constant time pressure, interruptions and disturbances at work, job responsibility, pressured to work overtime, increasing demands of the job
Reward	11	0.87	(Siegrist, 1996)	Respect/prestige, promotion prospects, undesirable change, job security, treated unfairly at work, adequate support and difficult situations
Intrinsic effort	6	0.80	(Siegrist, 1996)	Easily overwhelmed by time pressures at work, ability to relax and switch off work, sacrificing too much for the job etc
Social support	6	0.80	(Stansfeld et al., 2000)	Help and support and willingness to listen to work-related problems from work colleagues and immediate superior and quality of information from management
Role ambiguity	8	0.75	(Hurrell & McLaney, 1988)	Use of special skills and experience, training need, work meaningfulness, certainty about authority, clearly defined goals and plans, expectations and responsibilities
Role conflict	4	0.73	(Hurrell & McLaney, 1988)	Need to do things differently, incompatible requests, conflict with personal values, having assignments without adequate resources
Job future ambiguity	5	0.75	(Hurrell & McLaney, 1988)	Future career picture, opportunities for promotion and advancement, future use of skills, future responsibilities and ability to support yourself if you lost your job
Verbal abuse and/or confrontations	1	-	(Hurrell & McLaney, 1988)	The frequency of receiving verbal abuse and/or confrontations with clients or the general public
Threat of physical harm or injury	1	-	(Hurrell & McLaney, 1988)	The frequency of receiving threat of physical harm or injury etc
Job satisfaction	4	0.78	(Hurrell & McLaney, 1988)	Decide to take the same job if you could change, recommend the same job to friends, overall satisfaction with the job

Table 3 A summary of physical work factors measured in the baseline questionnaire

Construct	*Number of items*	*% agreement*	*Source*	*Comment*
Lifting 6-15kg Lifting 16-45 kg Lifting >45 kg	3	86 93 90	(Wiktorin et al., 1993)	Number of lifts per hour measured on a 5-point scale
General manual handling	2	-	(Houtman et al., 1994)	Push and pull with tasks requiring lifting, handling, heavy physical loads
Sitting on a chair or stool	4	78	(Devereux, 1997)	Sitting on a chair or stool, sitting and experiencing vibration, sitting and using a computer, uncomfortable sitting position
Standing	1	-	None	Standing in one position for 30 minutes or more without a break
Awkward posture	1	-	(Liira et al., 1996)	Always or often working with your back in an awkward position
Use of power tools	2	-	(Tanaka et al., 1997)	That makes the hands vibrate during the past week
Shoulder posture	3	39-100	(Li & Buckle, 1999)	Normally at waist, chest, at or above shoulder height
Repeated arm movement	1	78-89	(Li & Buckle, 1999)	Infrequently, frequently or very frequently
Wrist posture	2	67-94	(Li & Buckle, 1999)	Perform work with almost a straight wrist, with a deviated or bent wrist position
Repeated wrist movments	2	61-72	(Li & Buckle, 1999)	For much of the normal working day, how frequently
Neck posture	1	72-89	(Li & Buckle, 1999)	Occasionally or continuously working with the head/neck bent or twisted excessively
Keyboard use	10	-	(Hanson et al., 1999)	Less than two hours per day to over six hours per day measured on a four point scale

Table 4 A summary of outcome measures used in the baseline questionnaire

Construct	*N of items*	*Kappa*	*Source*	*Comment*
Lower back	16	-	(Punnett et al., 1991)	Problems more than three times or lasting more than one week in the previous year
Hand/wrists	17	0.84	(Franzblau et al., 1997)	Problems more than three times or lasting more than one week in the previous year
Elbow/Forearms	8	0.82	(Franzblau et al., 1997)	Problems more than three times or lasting more than one week in the previous year
Shoulder	9	0.76	(Franzblau et al., 1997)	Problems more than three times or lasting more than one week in the previous year
Neck	10	0.76	(Franzblau et al., 1997)	Problems more than three times or lasting more than one week in the previous year

[1] *Kappa value from the study cited in Source and refer to the item in Comment*

The frequency, duration and intensity of symptoms, problems in the last 7 days, radiating symptoms, medical history and functional impairment were measured for each outcome.

Table 5 A summary of psychological measures used in the baseline questionnaire

Construct	*N of items*	*Alpha*[1]	*Source*	*Comment*
Neuroticism	12	0.79	(Eysenck & Eysenck, 1985)	A trait scale comprising mood, sensitivity, nerves, tense, loneliness, guilt etc. 0.84 males, 0.80 females
Rumination	18	0.85	(Roger & Najarian, 1998)	Measures trait rumination, thinking over things that make you angry, reminders about upsetting things brings all the emotion back etc. 0.79
Mental health	12	0.86	(Goldberg & Williams, 1988)	GHQ-12 measures feeling under strain, ability to face up to problems, unhappy and depressed, not being able to concentrate, losing sleep over worry etc. 0.82-0.90
Perceived stress	10	0.85	(Cohen & Williamson, 1988)	Perceived life stress measured over the last month, feeling nervous and stressed, controlling irritations in your life, unable to control important things in your life etc.
Perceived job stress	1	-	(Smith et al., 2000)	Not at all stressful to extremely stressful on a five point scale
Depression	20	0.86	(Radloff, 1977)	CES-D measures clinical depression in epidemiological studies 0.84
Positive and negative mood	20	PA 0.90 NA 0.87	(Watson et al., 1988)	PANAS measures positive mood (10 items) and negative mood (10 items) 0.80
Satisfaction with life	5	0.89	(Pavot & Diener.E., 1993)	Satisfaction with life measures if life is close to your ideal, conditions are excellent, got the important things, nothing to change etc. 0.87
Lay beliefs about stress	36	Causes 0.83 Allev. 0.79	(Furnham, 1997)	Measures 22 and 14 items on causes and alleviation (allev.) of stress respectively. Refer to appendix 1 for items.
Psychosomatic complaints	16	0.79	(Hurrell & McLaney, 1988)	Measures headache, loss of appetite, feeling tense etc

[1] *Alphas from the study cited*

APPENDIX 9

Pilot study

A pilot study was conducted to assess questionnaire usability and administration methods before the baseline study was commenced. In total, 155 subjects from twelve companies were sent the draft baseline questionnaire. Fifty-four percent of subjects returned the questionnaire completed. In addition to the questionnaire, subjects also completed a feedback questionnaire concerning clarity of instructions, difficulties with the questions, questionnaire length, layout and preferred method for returning the questionnaires.

The overall feedback on the questionnaires was positive. The instructions were clear, questions were well laid out and the questions were interesting for 75% of respondents. About 20% of respondents believed the questionnaire was too long. As a result of the pilot study, the questionnaire was reduced substantially in length by eliminating sets of detailed questionnaire items relating to environmental conditions, self-esteem, coping and locus of control.

The data complied with expectations regarding the differences in prevalence between various definitions of musculoskeletal disorder symptoms. The data also reflected the types of work performed within each organisation that participated in the pilot study. The items on the questionnaire were able to appropriately classify workers into low and high exposure groups for risks of upper limb musculoskeletal disorder symptoms.

APPENDIX 10

Validation of study measures

The main data collection method was a self-report questionnaire. The validity of the data collected using a questionnaire was assessed by comparing questionnaire responses with data collected from an interview (for psychosocial exposure evaluation), a clinical examination (for musculoskeletal symptoms evaluation) and a video recording (for physical exposure evaluation).

1.1 Validation of exposure to psychosocial work factors

The validity of the self-report questionnaire for measuring psychosocial work factors was investigated by conducting 38 semi-structured interviews and 30 structured interviews with workers from organisations comprising the study population.

Participants from the Stress & MSD study cohort were asked to participate in this study. In total, 38 semi-structured interviews and 30 structured interviews were conducted. The semi-structured interviews were conducted across five organisations and the structured interviews were conducted across two organisations. Each organisation was from a different industrial sector.

A quiet office was provided by management at each of these sites where uninterrupted interviews were conducted. Subjects completing all the questionnaires within the Stress/MSD study were selected and then a forced sample with approximately the same number of subjects with low and high self-reported exposure within each company were asked to participate. Two dictaphones, with conference microphones, were used to record the interviews.

The context was introduced by a briefing in which one interviewer described the extent and objectives of the study to the subject, the purpose of the interview, the use of the tape recorder and the reasons for the consent form. Any questions raised by the interviewees were answered and the recorder switched on after the consent form was signed.

The 38 semi-structured interviews were carried out by one interviewer filling out the questionnaire as directed by the interviewee. During this process, the interviewer identified areas where it was considered that further enquiry was needed. The remainder of the interview was conducted based on these areas of further enquiry and the interview guide/reflection sheet containing acceptable unbiased probes. The second interviewer made notes of key themes throughout each interview only.

For the analysis, the tape recordings and interview/guide reflection sheets were analysed by both experienced interviewers. For each subject, the major themes recorded by the 2 interviewers were analysed separately from their own notes on another form and then the tape recording of the interview for each subject was played. The themes were verified and further themes were also recorded. An agreement was then reached between the two interviewers regarding the low or high exposure classification for each of the following constructs, Demands (Whitehall II items), Decision latitude (items from Whitehall II), Manager support (Whitehall II items),Co-worker support (Whitehall II items), Role stress (items from NIOSH JSI), Internal effort (items from Siegrist), Effort reward (items from Siegrist). Not all items from each construct were used, in order to minimise the length of the interview to minimise subject fatigue.

For the structured interviews, each subject was asked to complete the self-report questionnaire on a selection of psychosocial work factors used in the Stress & MSD study. The interviews were then conducted with the interviewer blind to the results of the questionnaire. The interviewer read each individual question to the interviewee and having listened to the answer, which sometimes involved the reasons for choices, asked the interviewee to make a choice between the alternatives markers on each sub-scale item presented on the questionnaire.

The sensitivity, specificity and positive predictive value were calculated in order to compare responses from the questionnaire with responses to the semi-structured and structured interviews. Role stress, internal effort and effort-reward were not assessed in the structured interviews because of the unacceptable length of the interview.

Table 1 Positive predictive value, sensitivity and specificity for psychosocial work factors measured by self-report and semi-structured and structured interviews

Factor	*Semi-structured interviews*			*Structured interviews*		
	PPV	***Sensitivity***	***Specificity***	***PPV***	***Sensitivity***	***Specificity***
Demands (N=4)	0.67	0.86	0.63	0.79	0.71	0.90
Decision latitude (N=9)	1.00	0.70	1.00	0.88	0.50	0.96
Manager support N=2)	0.63	0.83	0.88	0.82	0.56	0.90
Co-worker support (N=2)	0.50	0.33	0.96	0.56	0.56	0.86
Role stress (N=4)	0.67	0.25	0.97	-	-	-
Intrinsic effort (N=3)	0.64	0.50	0.83	-	-	-
Effort reward (N=3)	0.92	0.73	0.95	-	-	-

The positive predictive values ranged between 0.50-1.00 and 0.56-0.79 for semi-structured and structured interviews respectively. The sensitivity ranged between 0.25-0.86 and 0.56-0.71 for semi-structured and structured interviews respectively. The specificity ranged between 0.63-1.00 and 0.86-0.96 respectively (table 1).

In both types of interview, the sensitivity and specificity measures for each psychosocial work factor suggested acceptable classification of exposure using the self-report questionnaire according to the criteria in Armstrong et al. (1994). The sensitivity and specificity measures reported here may not be representative of the constructs used for classifying high and low exposure to psychosocial work factors in the study because the full scales were not used. However, the results did indicate that self-reported exposure to the items used in the constructs in the study were valid measures.

1.2 Validation of exposure to physical work factors

The validity of the self-report questionnaire for measuring physical work factors was investigated by conducting questionnaire based interviews and collecting video data for each of the 10 subjects participating in this validation study.

All the data was collected from one organisation involved in the study. The subjects involved in the data collection were production line workers constructing motor engine parts. An interviewer described the objectives of the study, the purpose of the interview and video data collection. Any questions raised by the subject were answered and informed consent was provided.

Each subject was asked to complete the self-report questionnaire for measuring exposure to a number of physical work factors (table 2). Each subject was then asked about the exposure to each item using an open-ended question. The interviewer then recorded any mismatches on the questionnaire. Each subject was video recorded twice within the same working day for a total of 15 minutes.

The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated, where possible, in order to compare responses from the questionnaire with exposure data analysed from the video data collection.

Table 2 Positive predictive value, negative predictive value, sensitivity and specificity for items used to assess exposure to physical work factors

	PPV	***NPV***	***Sensitivity***	***Specificity***
Repetitive arm movements	1.00	1.00	1.00	1.00
Repetitive wrist movements	1.00	-	1.00	-
Head/neck bent or twisted excessively	0.75	1.00	1.00	0.86
Push and pull combined with tasks requiring lifting	0.80	1.00	1.00	0.80
Elbow normally at or above shoulder height	-	1.00	-	1.00
Vibration from hand tools in the past week	-	1.00	-	1.00
Lifting 6-15kg greater than 10 times per hour or 16kg at all and always working in an awkward back posture	-	1.00	-	1.00

The positive predictive value could be calculated for repetitive arm movements, repetitive wrist movements, head/neck posture and pushing and pulling combined with tasks requiring lifting. The PPV ranged between 0.75-1.00 for these items. The negative predictive value could be calculated for all exposure items except repetitive wrist movements. All the exposure items had an NPV of 1.00 (table 2).

The sensitivity could be calculated for repetitive arm movements, repetitive wrist movements, head/neck posture and pushing and pulling combined with tasks requiring lifting. All the exposure items had a sensitivity of 1.00. The specificity could be calculated for all exposure items except repetitive wrist movements. The specificity ranged between 0.80-1.00.

The results indicated that the questionnaire could be used to accurately identify:-

- workers performing almost continuous arm movement and workers with regular arm movement with some pauses or workers with intermittent arm movement
- workers carrying out tasks involving repetitive movements of the wrists for much of the normal working day
- with working with the head/neck bent or twisted excessively and continuously, working with the head/neck bent or twisted excessively and occasionally or not working with the head/neck bent or twisted excessively
- workers pushing and pulling objects combined with tasks requiring lifting and workers not performing pushing and pulling
- not working with elbows normally at or above shoulder height
- not working with a power tool or machine that made the hands vibrate in the past week
- not lifting 6-15kg greater than 10 times per hour or 16kg at all and always working in an awkward back posture

The sensitivity and positive predictive value could not be calculated for the last three items in table 2. None of the 10 subjects were highly exposed to these factors. Likewise, the specificity and negative predictive value could not be calculated for the repetitive wrist movement item.

The sensitivity and specificity measures that could be calculated indicated acceptable classification of exposure to physical work factors using the self-report questionnaire according to the criteria in Armstrong et al. (1994). For the items with sensitivity measures, responses to these items accurately classified workers into a high exposure group. For the items with specificity measures, responses to these items accurately classified workers into a low exposure group.

1.3 Stability of exposures over time

A second questionnaire measuring exposure to physical and psychosocial work factors was administered to all baseline respondents approximately six months later. Of the 3139 subjects who returned the baseline questionnaire, 1806 subjects returned the exposure follow-up questionnaire. Forty-five subjects returned the questionnaire incomplete so completed response rate was 56% (n= 1761). Reminders were not circulated in this part of the study.

Ninety-three percent of the 1761 subjects reported no or minor changes (e.g. changes in working hours) in the tasks performed within their jobs in the last six months. The remaining 7% reported major changes (e.g. moving from manual work to office work) in the tasks performed within their jobs in the last six months. The results suggested that task changes during the follow-up were unlikely to result in changes in exposure classification in the cohort.

Each worker responding to the baseline study questionnaire was classified into a low and high exposure group for each physical and psychosocial work factor. Respondents who completed the second exposure questionnaire were also classified into low and high exposure groups for each physical and psychosocial work factor. Between 75-96% of workers at baseline were reclassified into the same exposure group six months after baseline (table 3).

Table 3 Percentage full agreement, kappa and 95% confidence interval for physical and psychosocial work factors measured at base-line and 6 months after base-line

Exposure factor	*% full agreement*	*Kappa*	*95% CI*
Job demands	74.8	0.46	0.42-0.50
Decision latitude	86.8	0.62	0.57-0.67
Work social support	70.4	0.41	0.36-0.45
Repetitive arm movements	82.1	0.47	0.41-0.52
Head/neck bent or twisted excessively	89.5	0.31	0.23-0.39
Lifting 6-15kg greater than 10 times per hour	95.1	0.65	0.58-0.73
Lifting 16-45kg at any frequency	87.8	0.69	0.65-0.73
Lifting greater than 45kg at any frequency	90.8	0.55	0.48-0.62
Elbow normally at or above shoulder height	95.8	0.43	0.32-0.55
Sitting and experiencing vibration more than half the time	95.7	0.74	0.68-0.80
Sitting and using a computer	91.5	0.82	0.79-0.85

The test-retest agreement for exposure classification of each physical and psychosocial work factor was determined using the kappa coefficient to ensure that the agreement was not due to chance alone. All the exposure factors in table 3 showed fair to excellent repeated exposure classification except for the head/neck bent or twisted excessively according to the criteria outlined in Fleiss (1986). This factor had relatively poor repeated exposure classification. The kappa coefficient for this factor was affected by the relatively low prevalence of workers with high exposure (3% of subjects).

The results suggested that a high proportion of workers maintained their exposure classification at baseline during the follow-up. The variation in exposure classification was affected more by measurement error using self-report questionnaire than by workers performing different work tasks during the follow-up.

The potential non-differential misclassification of exposure would make it harder to detect a true effect if one existed. An assessment of the reduction magnitude was about 0.3 for the odds ratio between exposure and musculoskeletal outcomes using an exposure item with one of the lowest measures of agreement. This suggested that the bias had a relatively small effect on the effect mangnitude.

Not all exposure factors were reassessed in the second questionnaire. It was necessary to assume that other physical and psychosocial work factors would show similar agreement between ratings of exposure.

1.4 Validation of self-reported musculoskeletal complaints

The validity of the self-report questionnaire for measuring musculoskeletal complaints was investigated by comparing responses from the questionnaire with physical findings from a clinical examination.

The main objective of this validation study was to assess whether self-reported musculoskeletal

complaints present as physical findings upon physical examination conducted by a qualified clinical examiner in a selected subset of the study population. This validation study was approved by the University of Surrey Committee on Ethics.

Subjects (n=82 in total) were selected from five of the participating organisations. Within each of the 5 companies, a group of workers with and without reported complaints were randomly selected from the follow-up sample population. About 50% of workers in each company had self-reported complaints in at least two of the following regions:- the lower back, the neck or the hands/wrists. Workers volunteering from the request for participation were selected as subjects.

Of the 82 subjects conducting the physical examination, 47 were male (42.7%) and 35 female (57.3%). This compared favourably with the gender distribution of the follow-up cohort, 38% male and 62% female subjects.

The examinations were performed approximately 12 weeks following the final follow-up questionnaire in the main study. Subjects were asked to complete a battery of questionnaires, which included a short form of the follow-up study questionnaire, the DASH (Hudak et al., 1996), the Revised Oswestry Low Back Pain and Disability Questionnaire (Fairbank et al., 1980) and the Neck Pain and Disability Index (Vernon-Mior), a set of Visual Analogue Pain Scales (rating pain right now, average pain in the past week, pain at its best and worst in the past week) and a full body pain diagram (recording dull, burning, numb, stabbing, tingling and cramping pain).

A comprehensive clinical musculoskeletal examination was conducted on each participant in order to identify signs of musculoskeletal dysfunction and/or pain. The examination criteria included postural assessment, tenderness to palpation (joint/muscle), active, passive and resisted ranges of motion, provocative orthopaedic tests for each area, muscle length and strength testing, neurological testing for balance and nerve tension and movement pattern assessment.

This examination protocol specifically assessed the cervical, thoracic and lumbopelvic spine and upper and lower limb extremity joints. The examination protocol utilised aspects of the Southampton Examination Schedule for the diagnosis of the upper limb (Palmer et al., 2000), and regional assessment procedures utilised at the University of Surrey Chiropractic Clinic. In addition to standard orthopaedic and neurological testing, chiropractic and functional joint evaluation examination procedures were integrated (Bergman et al., 1993).

The examination was designed not only to identify pain sensitive structures but also to identify dysfunctional joint and muscle complexes and sub-clinical areas of pain sensitivity.

In order to maximise the reliability of the examination protocol all examinations were performed by Dr JP Weston, an experienced and registered chiropractor.

Following an explanation of the study objectives and examination protocol, consent to examine was obtained from each participant. The examination duration was 20-30 minutes.

The examiner was blinded to the reported symptom status of each subject and did not review the case history of the patient prior to the examination. Any contraindications to examination for each subject was assessed prior to the examination by another researcher not involved with the clinical assessment.

Each subject was classified into a complaint or without complaint group for each body region from the questionnaire data. Each subject was also classified into a case (abnormal findings without pain or abnormal findings with pain) or non-case (normal findings) using the results

from the physical examination.

Examination data was analysed by area: 1) lumbopelvic 2) neck 3) upper back 4) shoulder 5) elbow and forearm 6) hand and wrist. These categories were selected to coincide with the self-report categories and integrated within the examination protocol to reflect functionally related areas.

Low-back complaints

At the time of the clinical examination, 27% (n=22) reported low back complaints. Pain intensity at the time of the examination was reported as a level of 2-5 by 31% of subjects (1 being no pain and 5 being intolerable pain).

In relation to the Revised Oswestry Questionnaire concerning activities of daily living (table 4), over 75% of subjects with self-reported low-back complaints also reported moderate to severe pain intensity and had pain when standing. Just over half the group reported that the degree of pain remained constant and that there was pain when walking. More than 25% reported pain on lifting, sitting and sleeping and pain affecting social life.

Table 4 Proportion of subjects with self-reported low-back complaints who experienced pain with activities of daily living

Items	*Proportion of subjects*
Pain intensity moderate to severe	81.3%
Pain on lifting	44.4%
Pain on walking	56.3%
Pain on sitting	25%
Pain on standing	75.1%
Pain affecting sleep	26.7%
Pain affecting social life	37.7%
Changing degree of pain	56.3% same 12.5% worsening
Severity of Pain 1-9	78.8%

Referring to table 5, about 80% of subjects reporting low-back complaints also reported abnormal findings producing pain on limited range of motion. A high proportion of subjects also had such findings for some provocative orthopaedic (lumbar kemps, Fabere Patrick) and palpation/trigger point tests (segmental mobility, quadratus lumborum TP, gluteus medius TP, Piriformis TP).

Interestingly, 40-80% of subjects reporting low-back complaints also had abnormal findings without pain sensation on a number of palpation/trigger points (e.g. quadratus lumborum TP, piriformis TP), movement pattern (squat and standing flexion) and length/strength tests (tensor fascia lata length, hip flexor length) and orthopaedic tests (straight leg arise and active hip extension).

Therefore, subjects reporting low-back complaints had a tendency to report functional impairment and had problems with daily living. A tendency was also observed in subjects not reporting low-back complaints but to a much lesser extent. Subjects with low-back complaints had up to 5.6 times more problems with pain affecting activities of daily living compared to subjects without complaints.

For the ROM, orthopaedic movement pattern and palpation tests most associated with self-reported complaints, sensitivity measures for correctly classifying subjects as cases ranged between 0.58-0.61. Specificity measures for correctly classifying subjects as non-cases ranged between 0.81-1.00.

Table 5 Proportion of subjects with self-reported low-back complaints with abnormal without pain findings or abnormal findings producing pain (N=22)

Physical findings	***Abnormal without pain***	***Abnormal with pain***
Range of Motion		
Range of Motion	18.2%	81.8%
Orthopaedic testing		
Lumbar Kemps	13.6%	63.6%
Straight leg raise	72.7%	13.6%
Fabere patrick	31.8%	36.4%
Yeomans	0.0%	13.6%
Leg length	95.5%	0.0%
Active hip extension	63.6%	9.1%
Movement patterns		
Standing flexion	72.6%	13.6%
Squat	72.7%	4.5%
Hip abduction	59.1%	13.6%
Hip extension	27.3%	27.3%
Palpation/Trigger Points		
Gillet test	27.7%	4.5%
Spinal scan	54.5%	18.2%
Prone full spine palpation	31.8%	40.9%
Segmental mobility	27.3%	50.0%
Quadratus lumborum TP	63.6%	36.4%
Multifidus TP	36.4%	22.7%
Gluteus medius TP	40.9%	40.9%
Piriformis TP	45.5%	36.4%
Gastrocnemius TP	63.6%	13.6%
Muscle Length/Strength		
Gluteal length	50.0%	22.7%
Hip flexor length	59.1%	18.2%
Psoas length	50.0%	0.0%
Tensor fascia lata length	59.1%	22.7%
Hamstring length	36.4%	9.1%
Quadriceps length	54.5%	0.0%
Piriformis length	40.9%	9.1%
Psoas strength	54.5%	0.0%
Abdominal strength	50.0%	4.5%

Self-reported neck complaints

Twenty-six percent of subjects presented with self-reported neck complaints at the time of the physical examination. Pain intensity at the time of the examination was reported as a level of 2-3 by 73% of subjects (1 being no pain and 5 being intolerable pain).

Activities of daily living as assessed by the Neck Disability Index revealed that half or more of subjects with self-reported neck complaints had moderate to severe pain severity, pain associated with reading, lifting and driving. Pain associated headaches were highly prevalent (81.3%) and more than 40% had pain affecting sleep (table 6).

Table 6 Proportion of subjects with self-reported neck complaints who experienced pain with activities of daily living

Items	*Proportion of subjects*
Pain intensity	50.0%
Pain on lifting	50.0%
Pain on reading	75.0%
Associated headache	81.3%
Pain on driving	62.5%
Neck pain affecting sleep	43.8%
Pain severity 1-9	68.8%

Referring to table 7, approximately 30-40% of subjects reporting neck complaints also had abnormal findings producing pain on sitting range of motion and some orthopaedic (kemps, doorbells and shoulder depression) and palpation/trigger point tests (PA segmental mobility and prone spinal palpation).

Interestingly, 40-80% of subjects reporting neck complaints also had abnormal findings without pain sensation on a number of postural (standing), palpation/trigger point (e.g. levator scapulae, upper trapezius), movement pattern (cervical flexion) and length/strength tests (neck flexion and lower trapezius).

Therefore, subjects reporting neck complaints had a tendency to report functional impairment and had problems with daily living. A tendency was also observed in subjects not reporting neck complaints but to a much lesser extent. Subjects with these complaints had up to 8.3 times more problems with pain affecting activities of daily living compared to subjects not reporting neck complaints.

For the ROM, orthopaedic and palpation tests most associated with self-reported complaints, sensitivity measures for correctly classifying subjects as case ranged between 0.37-0.42. Specificity measures for correctly classifying subjects as non-cases ranged between 0.77-0.83.

Table 7 Proportion of subjects with self-reported neck complaints with abnormal without pain findings or abnormal findings producing pain (N=21)

Physical findings	*Abnormal without pain*	*Abnormal with pain*
Posture		
Standing	61.9%	14.3%
Range of Motion		
Sitting ROM	23.8%	61.9%
Orthopaedic		
Shoulder depression	19.0%	33.3%
Shoulder abduction	42.9%	23.8%
Brachial plexus tension	9.5%	19.0%
Doorbell	19.0%	33.3%
Sitting cervical kemps	14.3%	33.3%
Movement Patterns		
Cervical flexion	47.6%	0.0%
Cervical stability	38.1%	0.0%
Cervical syndrome	38.1%	0.0%
Push-up	23.8%	0.0%
Palpation		
Spinal scan	47.6%	23.8%
SCM TP	28.6%	0.0%
Splenius capitus TP	33.3%	9.5%
Upper trapezius TP	81.0%	19.0%
Levator scapulae	71.4%	9.5%
Upper trapezius length	42.9%	4.8%
SCM length	33.3%	9.5%
Prone palpation	33.3%	38.1%
PA segmental mobility	28.6%	42.9%
Length/Strength		
Neck flexion strength	57.1%	14.3%
Neck extension strength	28.7%	0.0%
Lower trapezius strength	42.9%	0.0%

Upper back complaints

Ten percent of subjects reported upper back complaints at the time of the physical examination. Of the subjects reporting complaints, pain intensity at the time of the examination was reported as a level of 2-4 by 40% of subjects (1 being no pain and 5 being intolerable pain).

Activities of daily living as assessed by the Neck Disability Index revealed half or more of subjects with self-reported upper back complaints had pain associated with reading, lifting and sleeping. Pain associated headaches were highly prevalent (87.5%) (table 8).

Table 8 Proportion of subjects with self-reported upper back complaints who experienced pain with activities of daily living

Items	*Proportion of subjects*
Pain intensity	50.0%
Pain on lifting	50.0%
Pain on reading	62.5%
Associated headache	87.5%
Neck pain affecting sleep	50%
Pain severity 1-9	77.7%

Referring to table 9, 90% of subjects reporting upper back complaints also reported abnormal findings producing pain on sitting ROM. Approximately 30-40% of subjects reporting upper back complaints also reported abnormal findings producing pain on some palpation/trigger point tests (PA segmental mobility and prone spinal palpation).

Interestingly, 60-80% of subjects reporting upper back complaints also had positive abnormal without pain findings on a number of postural (standing), palpation/trigger point (e.g. levator scapulae, infraspinatus) and movement pattern tests (standing flexion).

Therefore, subjects reporting upper back complaints had a tendency to report functional impairment and had problems with daily living. A tendency was also observed in subjects not reporting upper back complaints but to a much lesser extent. Subjects with upper back complaints had up to 3.5 times more problems with pain affecting activities of daily living compared to subjects not reporting these complaints.

For the ROM, orthopaedic and palpation tests most associated with self-reported complaints, sensitivity measures for correctly classifying subjects as cases ranged between 0.19-0.40. Specificity measures for correctly classifying subjects as non-cases ranged between 0.81-1.00.

Table 9 Proportion of subjects with self-reported upper back complaints with abnormal without pain findings or abnormal findings producing pain (N=10)

Physical findings	*Abnormal without pain*	*Abnormal with pain*
Posture		
Standing	60.0%	20.0%
Range of Motion		
Sitting ROM	10.0%	90.0%
Orthopaedic		
Apley's scratch	70%	10.0%
Movement Patterns		
Standing flexion	80.0%	10.0%
Cervical flexion	60.0	0.0
Palpation		
Spinal scan	60.0%	23.8%
Trigger sub-scapularis	30.0	0.0%
Levator scapulae	80.0%	10.0%
Infraspinatus	60%	10%
Serratus post/sup	0.0%	30.0%
Prone FS palpation	20.0%	40.0%
PA segmental mobility	30.0%	40.0%
Length/Strength		
Rhomboids	20.0%	0.0%
Neck extension strength	20.0%	0.0%
Lower trapezius strength	20.0%	0.0%

Self-reported shoulder complaints

Thirty percent of subjects reported shoulder complaints at the time of the physical examination. For subjects reporting complaints, pain intensity at the time of the examination was reported as a level of 2-4 by 52% of subjects (1 being no pain and 5 being intolerable pain).

For subjects reporting shoulder complaints, over 50% of subjects also had difficulty opening a jar, carrying heavy objects, had mild to extreme pain in the last week and pain performing specific activities in the past week (table 10).

Between 30-50% of subjects reporting shoulder complaints also reported mild to severe difficulty opening a heavy door, placing an object on a shelf above the head, performing household chores, difficulty gardening, carrying shopping, changing a light bulb overhead, washing the back, difficulty performing recreational activities which require little effort, and were limited in their work or other regular daily activities as a result of arm, shoulder or hand of problems during the past week.

Table 10 Proportion of subjects with self-reported shoulder complaints who experienced pain with activities of daily living

Item	*Proportion of subjects*
Difficulty opening jar	56%
Difficulty heavy door	40%
Arms above head	48%
Pain on Heavy Chores	36%
Difficulty gardening	48%
Carrying shopping/case	48%
Carrying heavy objects	60%
Light bulb	36%
Washing back	36%
Recreational activities	44%
Pain affecting social activities	40%
Pain affecting work activities	36%
Pain mild to extreme	76%
Pain with specific activities	76%
Tingling	32%
Weakness	40%
Stiffness	50%
Difficulty with usual work	40%

Referring to table 11, 44% of subjects reporting shoulder complaints also reported abnormal findings producing pain on a shoulder range of motion test. Between 20-30% of subjects reported findings on some orthopaedic (impingement, shoulder depression, speeds) and movement pattern tests (sitting shoulder abduction).

Interestingly, 40-80% of subjects reporting shoulder complaints also had abnormal findings without pain sensation on a number of posture (standing), orthopaedic (apley's scratch, painful arc, shoulder abduction) and palpation tests (joint play, pectoralis major, infraspinatus).

Therefore, subjects reporting shoulder complaints also had a tendency to report functional impairment and had problems with daily living. This tendency was also observed in subjects not reporting shoulder complaints but to a much lesser extent. Subjects with shoulder complaints had up to 4.6 times more problems with pain affecting activities of daily living compared to subjects not reporting these complaints.

For the ROM, orthopaedic and movement pattern tests most associated with self-reported complaints, sensitivity measures for correctly classifying subjects as cases ranged between 0.44-0.60. Specificity measures for correctly classifying subjects as non-cases ranged between 0.72-0.75.

Table 11 Proportion of subjects with self-reported shoulder complaints with abnormal without pain findings or abnormal findings producing pain (N=25)

Physical findings	*Abnormal without pain*	*Abnormal with pain*
Posture	80.0%	8.0%
Range of Motion	28.0%	44.0%
Orthopaedic		
Impingement	12.0%	28.0%
Apley's Scratch	72.0%	0.0%
Speeds test	8.0%	20.0%
Painful Arc	40.0%	4.0%
Shoulder Depression	16.0%	20.0%
Shoulder abduction	56.0%	8.0%
Movement Patterns		
Sitting shoulder Abduction	28.0%	24.0%
Palpation		
Joint Play	44.0%	4.0%
Pectoralis Major TP	48.0%	0.0%
Supraspinatus TP	16.0%	12.0%
Infraspinatus TP	44.0%	12.0%
Muscle Length/Strength		
Supraspinatus strength	8.0%	16.0%

Self-reported elbow/forearm complaints

Twelve percent of the 83 subjects reported elbow/forearm complaints at the time of the physical examination. For subjects reporting elbow/forearm complaints, pain intensity at the time of the examination was reported as a level of 2-4 by 40% of subjects (1 being no pain and 5 being intolerable pain).

For subjects reporting elbow/forearm complaints, over 50% of subjects also had difficulty opening a jar, gardening, carrying heavy objects, washing back, had mild to extreme pain in the last week, pain performing specific activities in the past week and pain affecting social life in the past week. Ninety percent of subjects with elbow/forearm complaints also reported arm, shoulder or hand pain in the past week on performance of any specific activity using a separate questionnaire. Sixty percent of subjects reported difficulty performing their usual work because of the arm, shoulder or hand pain and 60% also reported difficulty spending the usual amount of time doing their work (table 12).

Between 30-50% of subjects reporting elbow/forearm complaints also reported mild to severe difficulty writing, pushing open a heavy door, difficulty with heavy household chores, making a bed, and changing a light bulb, and sleeping during the past week because of the pain in the arm, shoulder or hand.

Table 12 Proportion of subjects with self-reported symptoms of elbow/forearm complaints who experienced pain with activities of daily living

Items	*Proportion of subjects*
Difficulty opening tight jar	80%
Difficulty writing	40%
Difficulty pushing heavy door	40%
Difficulty heavy household chores	50%
Gardening	60%
Making bed	40%
Carrying shopping	50%
Carrying heavy object	70%
Changing light bulb	40%
Washing back	60%
Pain affecting social life	70%
Pain affecting work	70%
Arm/hand/shoulder pain	90%
Pain performing specific activity	90%
Weakness	70%
Stiffness	60%
Sleeping difficulty	50%
Usual work different	60%
Usual amount of time at work different	60%

Referring to table 13, 30% of subjects reporting elbow/forearm complaints also reported abnormal findings producing pain on an elbow range of motion test and a palpation/trigger point test (elbow palpation). Interestingly, 50-60% of subjects reporting elbow/forearm complaints also had positive abnormal without pain findings on a palpation test (Pronator Teres TP).

Therefore, subjects reporting elbow/forearm complaints had a tendency to report functional impairment and had problems with daily living. This tendency was also observed in subjects not reporting elbow/forearm complaints but to a much lesser extent. Subjects with elbow/forearm complaints had up to 24 times more problems with pain affecting activities of daily living compared to subjects not reporting these complaints.

For the ROM and palpation tests most associated with self-reported complaints, sensitivity measures for correctly classifying subjects as cases ranged between 0.23-0.60. Specificity measures for correctly classifying subjects as non-cases ranged between 0.89-0.90.

Table 13 Proportion of workers with self-reported symptoms of elbow/forearm complaints with abnormal without pain findings or abnormal findings producing pain (N=10)

Physical Findings	*Abnormal without pain*	*Abnormal with pain*
Range of Motion		
Elbow	0.0%	30.0%
Orthopaedic		
Lateral /collateral Ligament	33.3%	11.1%
Medial Collateral Ligament	20.0%	0.0%
Cozen's test	0.0%	20.0%
Palpation		
Pronator Teres TP	50.0%	0.0%
ECRL TP	30.0%	10.0%
Mfext TP	30.0%	0.0%
Supinator TP	30.0%	0.0%
Elbow Palpation	10.0%	30.0%
Joint play	10.0%	10.0%

Self-reported hand/wrist complaints

Thirty percent of subjects reported hand/wrist complaints at the time of the physical examination. Of the subjects reporting hand/wrist complaints, pain intensity at the time of the examination was reported as a level of 2-5 by 40% of subjects (1 being no pain and 5 being intolerable pain).

For subjects reporting hand/wrist complaints, the evaluation of reported disability of the arm, shoulder and hand, as assessed by the DASH, revealed that over 50% of subjects also had difficulty opening a jar, gardening and carrying heavy objects and difficulty doing their usual work. Seventy-six percent of subjects reported arm, shoulder or hand pain in the past week and 72% experienced arm, shoulder or hand pain when performing any specific activity (table 14).

Between 40-50% of subjects reporting hand/wrist complaints also reported tingling (pins and needles), weakness and stiffness in the arm, shoulder or hand in the last week at the time of the physical examination.

Table 14 Proportion of subjects with self-reported hand/wrist complaints who experienced pain with activities of daily living

Items	*Proportion of subjects*
Open jar	52%
Gardening mild-severe	52%
Pain arm/shoulder/hand	76%
Carry heavy object	52%
Pain specific activity	72%
Tingling	40%
Weakness	48%
Stiffness	49%
Different usual work	52%

Table 15 Proportion of subjects with self-reported hand/wrist complaints with abnormal without pain findings or abnormal findings producing pain (N=25)

Physical Findings	*Abnormal without pain*	*Abnormal with pain*
Range of Motion		
Wrist	24%	20%
Elbow	8%	16%
Orthopaedic		
Finklesteins	12%	16%
Lateral collateral ligament	16%	20%
Cozen's	0.0%	12%
Mills	4%	16%
Palpation		
Wrist JP	36%	16%
Mfextensor TP	44%	24%
ECRL TP	20%	16%
Elbow palpation	16%	28%

Referring to table 15, between 20-30% of subjects reporting hand/wrist complaints also reported abnormal findings producing pain on a wrist range of motion test, an orthopaedic test (lateral collateral ligament) and two palpation tests (middle finger extensor TP, elbow palpation).

Interestingly, 20-30% of subjects reporting hand/wrist complaints also had abnormal findings without pain sensation on a number of ROM (wrist) and palpation (Wrist JP, middle finger extensor TP) tests.

Therefore, subjects reporting hand/wrist complaints had a tendency to report functional impairment and had problems with daily living. This tendency was also observed in subjects not reporting hand/wrist complaints but to a much lesser extent. Subjects with hand/wrist complaints had up to 7.4 times more problems with pain affecting activities of daily living compared to subjects not reporting these complaints.

For the ROM, orthopaedic and palpation tests most associated with self-reported complaints, sensitivity measures for correctly classifying subjects as cases ranged between 0.42-0.63. Specificity measures for correctly classifying subjects as non-cases ranged between 0.74-0.76.

Conclusion of the validation study

The main objective of this validation study was to assess whether self-reported musculoskeletal complaints were indicative of abnormal findings in a physical examination and indicated some degree of functional impairment or problems with activities of daily living.

The sensitivity was lower than the specificity for each region indicating that the self-report questionnaire was better at identifying subjects with normal physical findings compared to subjects with abnormal physical findings. The specificity of the self-report questionnaire was very high and identified all normal subjects for some tests of the lower back and upper back.

The sensitivity and specificity measures for each region suggested acceptable outcome classification using the self-report questionnaire according to the criteria outlined in Armstrong et al. (1994).

A high proportion of subjects with self-reported musculoskeletal complaints had difficulty performing everyday tasks without making their problems worse. At the time of the physical examination many subjects reporting musculoskeletal complaints were not in any significant pain. The sensitivity measures may have been much higher if more subjects were in pain due to their complaints at the time of the examination.

This validation study suggests that the outcome measures used in this epidemiological study were suitable for identifying subjects with functional impairment and positive abnormal findings upon physical examination. The outcomes measures used for assessing musculoskeletal complaints in the neck, shoulder or upper limbs have also been shown in another study to be reliable (good to excellent test-retest reliability) and suitable for use in epidemiological studies (Franzblau et al., 1997).

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