# PATTERNS OF CHANGE OF MULTISITE PAIN OVER ONE YEAR OF FOLLOW-UP AND RELATED RISK FACTORS

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**Conflict of interest statement**

None declared.

**What’s already known about this topic?**

Multisite musculoskeletal pain is common in working populations but prevention strategies usually focus on ergonomic factors which tend to influence single-site pain.

**What does this study add?**

Among workers from 18 countries, there was reasonable consistency in the total number of reported painful sites. Yet, the anatomical distribution of painful sites often changed, supporting the hypothesis of an important role for central pain sensitisation mechanisms, rather than localised risk factors, among working adults.

**Abstract**

**Background**

Multisite musculoskeletal pain is common and disabling. This study aimed to prospectively investigate distribution of musculoskeletal pain anatomically, and explore risk factors for increases/reductions in the number of painful sites.

**Methods**

Using data from participants working in 45 occupational groups in 18 countries, we explored changes in reporting pain at 10 anatomical sites on two occasions 14 months apart. We used descriptive statistics to explore consistency over time in the number of painful sites, and their anatomical distribution. Baseline risk factors for increases/reductions by ≥3 painful sites were explored by random intercept logistic regression that adjusted for baseline number of painful sites.

**Results**

Amongst 8,927 workers, only 20% reported no pain at either time point, and 16% reported ≥3 painful sites both times. After 14 months, the anatomical distribution of pain often changed but there was only an average increase of 0.17 painful sites. Some 14% workers reported a change in painful sites by ≥ 3. Risk factors for an increase of ≥ 3 painful sites included female sex, lower educational attainment, having a physically demanding job, and adverse beliefs about the work-relatedness of musculoskeletal pain. Also predictive were: older age, somatising tendency, and poorer mental health (each of which was also associated with lower odds of reductions of ≥ 3 painful sites).

**Conclusions**

Longitudinally, the number of reported painful sites was relatively stable but the anatomical distribution varied considerably. These findings suggest an important role for central pain sensitisation mechanisms, rather than localised risk factors, among working adults.

**Word count 250**

**Significance**

Our findings indicate that within individuals, the number of painful sites is fairly constant over time, but the anatomical distribution varies, supporting the theory that among people at work, musculoskeletal pain is driven more by factors that predispose to experiencing or reporting pain rather than by localised stressors specific to only one or two anatomical sites.

# Introduction

Musculoskeletal pain frequently affects multiple anatomical sites in the same individual ([Carnes et al., 2007](#_ENREF_2); [Hartvigsen, Davidsen, et al., 2013](#_ENREF_13); [Hartvigsen, Natvig, et al., 2013](#_ENREF_14)), impacting importantly on daily functioning ([Y. Kamaleri et al., 2008](#_ENREF_19); [Saastamoinen et al., 2006](#_ENREF_25)), work ability, healthcare seeking ([Mose et al., 2021](#_ENREF_21)) and sickness absence ([Neupane et al., 2015](#_ENREF_22)). We have previously shown large international differences in the prevalence of multi-site pain amongst working populations ([D. Coggon et al., 2013](#_ENREF_6)), while other research has suggested that within individuals, the extent of musculoskeletal pain (as indicated by the number of anatomical sites affected) remains fairly constant over periods of two years or longer ([Christensen et al., 2017](#_ENREF_4); [Kamaleri et al., 2009](#_ENREF_18)). Together, these findings suggest causes with long-lasting action or effect, exposure to which varies importantly between countries.

Observational studies have identified various risk factors for multisite musculoskeletal pain. Some, such as somatising tendency ([Christensen et al., 2017](#_ENREF_4); [D. Coggon et al., 2013](#_ENREF_6); [Croft et al., 1993](#_ENREF_8); [Gupta et al., 2007](#_ENREF_12)) and poorer mental health ([Christensen et al., 2017](#_ENREF_4); [Croft et al., 1993](#_ENREF_8); [Haukka et al., 2011](#_ENREF_15)), may act through central mechanisms of pain perception. Others, such as occupational tasks that mechanically load the musculoskeletal system ([D. Coggon et al., 2013](#_ENREF_6); [Neupane et al., 2016](#_ENREF_23)), are likely to be more local in their action. For example, work with the hands above shoulder height would be expected to impact principally on pain in the shoulder and neck. However, in combination with other risk factors, such exposures could still contribute importantly to the occurrence of more widespread pain.

If the persistent extent of pain within individuals were driven largely by continuing exposure to a combination of causes, each acting locally at different anatomical sites, one might expect that within individuals, the anatomical distribution of pain (i.e. which anatomical sites were affected) would be fairly constant over time. On the other hand, persistent number of painful sites, but with an anatomical distribution that fluctuated over time might suggest a long-term effect of one or more risk factors that rendered individuals more susceptible to musculoskeletal pain in general.

To explore whether musculoskeletal pain is consistent over time in its anatomical distribution as well as number of painful sites, we analysed longitudinal data from the Cultural and Psychosocial Influences on Disability (CUPID) study. We also explored risk factors for increases or decreases of ≥ 3 in the number of painful sites over time.

**Methods**

The methods of the CUPID study have been described in detail elsewhere ([David Coggon et al., 2012](#_ENREF_5)). In brief, the CUPID study included workers aged 20-59 years from 47 occupational groups in 18 countries. The occupational groups fell into three broad categories – nurses, office workers, and “other workers”, the latter mainly carrying out repetitive manual tasks with their hands or arms. Participants completed a baseline questionnaire, which included items about musculoskeletal pain, related disability, and possible risk factors. Questionnaires were mainly self-administered, but in a few occupational groups, were completed by interview.

The questionnaire was originally drafted in English, and then where necessary, translated into local languages (accuracy being checked by independent back-translation to English). Among other things, it asked whether the participant had experienced pain that had lasted for at least one day in the past month, at each of 10 anatomical sites (neck, right/left shoulder, right/left elbow, right/left wrist/hand, lower back, and right/left knee), which were depicted in diagrams. It also included questions about demographic characteristics (sex, age, education); smoking habits (categorised as never smoked, ex-smoker or current smoker); somatising tendency; mental health; hours worked per week (< or ≥ 50); physical demands of work; psychosocial aspects of work (time pressure; lack of support from colleagues or supervisor/manager; job dissatisfaction); and beliefs about the relationship of musculoskeletal pain to work and physical activity.

Somatising tendency was assessed using questions from the Brief Symptom Inventory ([Derogatis and Melisaratos, 1983](#_ENREF_10)), and scored according to how many of the five common somatic symptoms had been at least moderately distressing in the past week (grouped into three categories: 0, 1, ≥2). Mental health was assessed using items from the Short Form-36 questionnaire ([Ware and Sherbourne, 1992](#_ENREF_28)), with scores grouped into three categories (good, intermediate, and poor) corresponding approximately to thirds of their distribution in the full study sample.

Physically demanding work was scored according to the number of work activities from a list of five (lifting weights of ≥25 kg by hand; working >1 hour in total with the hands above shoulder height; repeated bending and straightening of the elbow for >1 hour in total; repeated movements of the wrist or fingers for >4 hours in total; and kneeling or squatting for >1 hour in total) that were reported as being carried out in an average working day.

Participants were considered to have adverse beliefs about: i) the work-relatedness of musculoskeletal pain – if they completely agreed that pain, either in the low back or arm, is commonly caused by people’s work, and ii) physical activity – if they completely agreed that in a person with low back or arm pain, physical activity should be avoided and also that rest is needed to get better.

Approximately 14 months after completion of the baseline questionnaire, participants from 45 of the original 47 occupational groups were re-surveyed with a shorter follow-up questionnaire, which again included questions about pain lasting for at least a day in the past month, by anatomical site.

*Statistical analysis*

We initially described the distribution of participants according to report of pain by anatomical site, and the number of painful sites in the past month, at baseline and at follow-up. For each anatomical site, we assessed concordance between report of pain at baseline and at follow-up, using the kappa statistic.

We then assessed the degree to which distribution of pain at baseline and follow-up was driven by pain occurring at the same anatomical sites at both time points. To do this, we used a measure of consistency defined for each participant according to the total numbers of anatomical sites that were painful at baseline (), follow-up (), and both time points (). We first calculated the minimum and maximum number of sites that could be painful at both time points, given the values for () and (), by applying the formulae:

Minimum possible concordance = max [( + – 10),0]

Maximum possible concordance = min [,]

We then calculated the consistency as the difference between the observed concordance and the minimum possible concordance expressed as a percentage of the difference between the maximum and minimum possible concordances:

Consistency = ( – max [( + – 10),0]) \* 100 / (min [,] – max [( + – 10),0])

For each participant, we also calculated the change from baseline to follow-up in the number of painful anatomical sites. Based on the distribution of that change, we distinguished people with: a) an improvement in the number of painful sites (defined as a reduction of ≥3 in the number of painful sites); b) a deterioration in the number of painful sites (defined as an increase of ≥3 in the number of painful sites); and c) smaller or no change in the number of painful sites. Baseline risk factors for improvement and deterioration in the number of painful sites were mutually assessed by logistic regression, taking participants with smaller or no change as the reference. The regression models adjusted for the number of painful sites in the month before baseline and included random intercepts to account for possible clustering by occupational group. Effect estimates were summarised by odds ratios (OR) with 95% confidence intervals (CI).

Ethical approval for the study was provided by the relevant research ethics committee or institutional review board in each participating country. All analyses were carried out using Stata software (Stata Corp LP 2012, Stata Statistical Software: Release 12.1, College Station TX, USA).

**Results**

Among workers initially eligible for inclusion in the study, a total of 12,426 completed the baseline questionnaire (response rate = 70%), and within the subset of 11,992 from the 45 occupational groups that were followed-up, 9,305 (78%) also completed the second questionnaire. Follow-up rates, which varied from 38% to 97%, across the 45 occupational groups, were somewhat higher among older participants, those who were better educated, office workers, non-smokers, and those with good mental health (data not shown). Amongst those followed-up, 8,927 (96%) provided useable information at both time points about pain in the past month by anatomical site and could be included in current analyses.

Table 1 shows the distribution of participants according to the one-month prevalence of site-specific pain at baseline and follow-up. At both time points, the sites most commonly affected were the lower back and neck, while those affected least were the right and left elbow and left wrist/hand. Consistency over time indicated only “fair” agreement between baseline and follow-up, (kappa values by site ranging from 0.23 for the left elbow to 0.41 for the neck).

The distribution of participants according to the number of painful sites at baseline and follow-up is presented in Table 2. Approximately 20% of participants (N=1,782) reported no painful sites either at baseline or follow-up, while 16% (N=1,461) reported three or more painful sites at both time points. Just over 15% (N=1,420) reported the same number of painful sites at both baseline and follow-up. A higher number of participants reported an increase in the number of painful sites (N=3,234 including N=1,519 with no affected sites at baseline) than a reduction (N=2,491 including N=961 with no painful sites at follow-up). The increase in the mean number of painful sites between baseline and follow-up was 0.17 (95% CI: 0.14-0.21) (mean number of painful sites 1.67, 95% CI: 1.63-1.71, at baseline; and 1.85, 95% CI: 1.81-1.89, at follow-up).

Table 3 summarises the consistency of the anatomical distribution of pain according to the numbers of anatomical sites affected at baseline and at follow-up. The average consistency was 70.8% overall, and 62.4% among the 1,414 participants in whom the number of painful sites was unchanged from baseline to follow-up.

Most participants experienced only a modest change in the number of painful sites from baseline to follow-up. For 86% of the study sample, the difference was between -2 and +2, including over one third (N=3,202) with no change at all (Fig. 1). However, for a minority the change was greater, 537 (6%) reporting a reduction of ≥3 painful sites, and 752 (8%) an increase of ≥3 painful sites. Taking those with a difference from -2 and +2 as a reference, we used logistic regression to explore risk factors at baseline for larger reductions and increases in the number of painful sites (Table 4). Older age, somatising tendency, and poorer mental health were significantly associated with both lower odds of improvement and higher odds of deterioration in the extent of musculoskeletal pain between baseline and follow-up. In addition, females, and those with lower educational attainment, more physically demanding jobs, and adverse health beliefs about the work-relatedness of musculoskeletal pain were more likely to report increases in the number of sites of musculoskeletal pain. In contrast, no associations were found with the psychosocial aspects of work that were examined.

In further analyses we included baseline specific pain sites in the final mutually adjusted models. Even though specific painful sites at baseline were associated with progression of pain at follow-up, with the direction of effect being that one would expect (for example neck pain at baseline increasing the risk of deterioration in the extent of musculoskeletal pain from baseline to follow-up), none of the associations was significant (data not shown).

**Discussion**

Our study explored changes in the anatomical distribution and number of painful sites after an interval of approximately 14 months, in a large sample of workers from 18 countries. While there was reasonable consistency in the total number of sites that participants reported as painful, the anatomical distribution of sites reported as painful often changed. Risk factors for deterioration in the extent of pain included older age, somatising tendency, and poorer mental health (each of which was associated also with lower odds of improvement), as well as female sex, lower educational attainment, having a job that was more demanding physically, and adverse health beliefs about the work-relatedness of musculoskeletal pain. These findings are consistent with the hypothesis that musculoskeletal pain in working populations is driven more by factors that predispose to musculoskeletal pain in general than by causes specific to particular anatomical sites.

Our study had the advantage of a longitudinal design, with a good response rate at follow-up from a large and culturally diverse sample of participants. Data on pain at ten anatomical sites and a wide range of potential risk factors were collected through standardised questions, many of which were taken, or modified, from established and widely used instruments ([David Coggon et al., 2012](#_ENREF_5)).

There are, however, several potential limitations that need to be considered in interpretation of the findings. Firstly, although the study was restricted to workers from a limited range of occupations, we believe that the sample is representative of the general adult population with respect to consistency over time in the number of painful sites or anatomical distribution of pain, or the association of risk factors with changes in pain over time. More important is the possibility that some participants in the baseline survey were selectively lost to follow-up because of subsequent musculoskeletal pain (e.g. if it caused them to leave their job). This healthy worker effect may have caused some underestimation of the average increase in the number of painful sites, but we would not expect any effect on the consistency of the anatomical distribution of painful sites within individuals, the measure of which was conditioned on the number of painful sites reported both at baseline and at follow-up.

Secondly, risk factors were also ascertained through self-report, which may have been influenced by subjective perceptions. This could lead to bias if people more prone to report musculoskeletal pain tended also to perceive and report greater exposure to one or more specific risk factors ([Podsakoff et al., 2003](#_ENREF_24)). However, any such bias should have been controlled for by the inclusion of number of painful sites at baseline as a factor of adjustment in our regression analyses. Lastly, the cut-point by which we defined changes in the total number of painful sites was to some extent arbitrary, but this cut-off was chosen before any associations with risk factors were examined. Therefore, their specification should not have been a source of bias. We additionally performed sensitivity analyses using different cut-points (≥2 and ≥4 painful sites) and results were very similar to those shown in Table 4 (data not shown). Overall, we do not think that these limitations call into question the main findings from our study.

Two other investigations have also indicated that the number of painful musculoskeletal sites is fairly stable over time. In Norway, Kamaleri and colleagues explored patterns of reported pain at 10 anatomical sites in six birth cohorts ([Kamaleri et al., 2009](#_ENREF_18)). After 14 years, the mean number of painful sites had increased by 0.5, and in 46% of participants, the number of painful sites was unchanged or changed by only one. Another Norwegian study, which followed up a cohort of employed adults, found that after a two-year interval, the number of painful sites was the same to within +/- 1 in 79.3% of participants ([Christensen et al., 2017](#_ENREF_4)).

We have found more limited research that has considered the consistency over time in the anatomical distribution of multisite pain. Considering pain in each of four sites: the neck, shoulder, hand/elbow and low back, Gummesson and colleagues compared the consistency of reporting pain “often/all the time” at the same site 12 months later amongst >12,000 people with mean age 57.2 years ([Gummesson et al., 2006](#_ENREF_11)). They found that the prevalence of reporting long-lasting pain in any body region changed little over 12 months of follow-up: reported by 34% of men (46% of women) at baseline and 32% of men (44% of women) at follow-up. However individual changes in the pain reporting were observed so that e.g. only 48% of men and 54% of women who reported neck pain “all the time” at baseline still reported neck pain “all the time” at follow-up with this same transition observed at each body region. Similar transitions have been described for incidence and persistence of pain at specific anatomical sites, including the neck ([Côté et al., 2004](#_ENREF_7)), and shoulder-neck ([Andersson et al., 1996](#_ENREF_1)) and for chronic widespread pain ([McBeth et al., 2001](#_ENREF_20)). A systematic review including 33 cohorts and >11,000 participants with low back pain found that most episodes of low back pain improved substantially within 6 weeks and that by 12 months, average pain intensity levels were low (scored at 6 points out of 100) ([Shiri and Falah-Hassani, 2017](#_ENREF_26)) but that 67% of people reported persistence of low back pain after 3 months of follow-up and 65% (95% CI 54-75%) reported persistence after 12 months of follow-up ([da C Menezes Costa et al., 2012](#_ENREF_9); [Itz et al., 2013](#_ENREF_16)).

Although participants in our study were mostly fairly consistent from baseline to follow-up in the number of anatomical sites which they reported as painful, a minority experienced substantial changes in the number of painful sites. We found that older participants, those who tended to somatise and those with poorer mental health were more likely to report an increase by ≥3 in the number of painful sites, and less likely to report reduction of such magnitude. Additionally, an increase by ≥3 sites was significantly associated with female sex, lower educational attainment, work that was physically demanding, and adverse beliefs about the work-relatedness of musculoskeletal pain. These associations are broadly consistent with those that we found in an earlier cross-sectional analysis of data from the CUPID study ([D. Coggon et al., 2013](#_ENREF_6)), and with findings from other cross-sectional and longitudinal studies of risk factors for multisite or widespread pain ([Cho et al., 2012](#_ENREF_3); [Christensen et al., 2017](#_ENREF_4); [Croft et al., 1993](#_ENREF_8); [Gupta et al., 2007](#_ENREF_12); [Haukka et al., 2011](#_ENREF_15); [Yusman Kamaleri et al., 2008](#_ENREF_17); [Neupane et al., 2016](#_ENREF_23)). In particular, multisite pain has been linked to female sex ([Cho et al., 2012](#_ENREF_3); [D. Coggon et al., 2013](#_ENREF_6); [Yusman Kamaleri et al., 2008](#_ENREF_17); [Neupane et al., 2016](#_ENREF_23)), older age ([Cho et al., 2012](#_ENREF_3); [D. Coggon et al., 2013](#_ENREF_6); [Neupane et al., 2016](#_ENREF_23)), other somatic symptoms ([Christensen et al., 2017](#_ENREF_4); [D. Coggon et al., 2013](#_ENREF_6); [Croft et al., 1993](#_ENREF_8); [Gupta et al., 2007](#_ENREF_12)), poor mental health ([Christensen et al., 2017](#_ENREF_4); [Croft et al., 1993](#_ENREF_8); [Haukka et al., 2011](#_ENREF_15)) and physically demanding work ([D. Coggon et al., 2013](#_ENREF_6); [Neupane et al., 2016](#_ENREF_23)). The relationship to older age could reflect degenerative changes that affect the musculoskeletal system in general. The relationship with physically demanding work (which was scored according to a range of activities that would mechanically load different parts of the body) might indicate either that such loading causes painful pathology, or that it increases awareness of pain. The other risk factors could all be associated with differences in the central processing of sensory stimuli which render people more susceptible to pain.

Previous investigations have shown associations of multisite pain also with psychosocial aspects of work such as time pressure ([D. Coggon et al., 2013](#_ENREF_6)), job dissatisfaction ([Neupane et al., 2016](#_ENREF_23); [Solidaki et al., 2010](#_ENREF_27)), and lack of employer or co-worker support ([D. Coggon et al., 2013](#_ENREF_6); [Haukka et al., 2011](#_ENREF_15); [Solidaki et al., 2010](#_ENREF_27)). However, in our study, those factors were not found to be associated with increases in the extent of musculoskeletal pain. It may be that the determinants of multisite pain are different from those that determine increases in the number of reported painful sites or that their effects were too small to be detected over 14 months of follow-up.

Our observation that within individuals, the number of painful sites is fairly constant over time, while its anatomical distribution varies, supports the theory that among people at work, musculoskeletal pain is driven more by factors that predispose to pain rather than by localised stressors specific to only one or two anatomical sites. There is no obvious reason why increase in exposure to a risk factor specific to one site would tend to be compensated by reductions in exposure to risk factors specific to other sites. Moreover, most of the risk factors that we found for increase in the extent of pain would be expected to reflect central mechanisms of pain perception. As such, our results reinforce the case for looking beyond local mechanical loading of tissues when developing strategies for the prevention of musculoskeletal pain in working populations.

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**Authors’ contribution**

David Coggon initiated and coordinated the CUPID study, and led data collection in the UK; Georgia Ntani carried out the statistical analysis and wrote the first draft of the manuscript jointly with Karen Walker-Bone and David Coggon; Florencia Harari led data collection in Ecuador; Lope Barrero led data collection in Colombia; Sarah Felknor and Marianela Rojas led data collection in Costa Rica and Nicaragua; Anna Cattrell coordinated data collection in the UK; Consol Serra led data collection in Spain; Matteo Bonzini led data collection in Italy; Eda Merisalu led data collection in Estonia; Rima Habib led data collection in Lebanon; Farideh Sadeghian led data collection in Iran; A Rajitha Wickremasinghe jointly supervised data collection in Sri Lanka; Ko Matsudaira led data collection in Japan; Busisiwe Nyantumbu-Mkhize led data collection in South Africa; Helen L Kelsall coordinated data collection in Australia; Helen Harcombe led data collection in New Zealand

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#### **Table 1** Distribution of participants according to site-specific pain in past month at baseline and at follow-up

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Anatomical site** |  | **Pain in past month at baseline and at follow-up** | | | |  | **Kappa** |
|  |  | **-/-** | **+/-** | **-/+** | **+/+** |  |  |
|  |  |  |  |  |  |  |  |
| Low back |  | 4,200 | 1,174 | 1,483 | 2,070 |  | 0.370 |
|  |  |  |  |  |  |  |  |
| Neck |  | 4,744 | 973 | 1,394 | 1,816 |  | 0.407 |
|  |  |  |  |  |  |  |  |
| Right shoulder |  | 6,223 | 859 | 1,028 | 817 |  | 0.333 |
|  |  |  |  |  |  |  |  |
| Left shoulder |  | 6,838 | 743 | 850 | 496 |  | 0.280 |
|  |  |  |  |  |  |  |  |
| Right elbow |  | 7,849 | 375 | 483 | 220 |  | 0.288 |
|  |  |  |  |  |  |  |  |
| Left elbow |  | 8,218 | 287 | 316 | 106 |  | 0.225 |
|  |  |  |  |  |  |  |  |
| Right wrist/hand |  | 6,664 | 726 | 809 | 728 |  | 0.384 |
|  |  |  |  |  |  |  |  |
| Left wrist/hand |  | 7,394 | 514 | 637 | 382 |  | 0.327 |
|  |  |  |  |  |  |  |  |
| Right knee |  | 6,716 | 705 | 835 | 671 |  | 0.363 |
|  |  |  |  |  |  |  |  |
| Left knee |  | 6,887 | 690 | 757 | 593 |  | 0.355 |

-/- indicates no symptom at either baseline or follow-up; +/- indicates symptom being present at baseline only; -/+ indicates symptom being present at follow-up only; +/+ indicates symptom being present at both baseline and follow-up

#### **Table 2** Distribution of participants according to number of anatomical sites with pain in past month at baseline and follow-up

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Number of anatomical sites with pain at baseline** |  | **Number of anatomical sites with pain in past month at follow-up** | | | | | | | | | | |
|  | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **0** |  | 1,782 | 756 | 401 | 198 | 92 | 39 | 17 | 11 | 2 | 2 | 1 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **1** |  | 526 | 596 | 369 | 211 | 102 | 44 | 15 | 14 | 5 | 1 | 0 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **2** |  | 234 | 310 | 378 | 233 | 136 | 52 | 23 | 7 | 4 | 3 | 1 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **3** |  | 115 | 157 | 206 | 220 | 116 | 68 | 34 | 20 | 6 | 2 | 0 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **4** |  | 40 | 58 | 111 | 144 | 113 | 55 | 29 | 19 | 16 | 2 | 4 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **5** |  | 21 | 38 | 56 | 52 | 62 | 59 | 28 | 21 | 6 | 4 | 0 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **6** |  | 14 | 17 | 26 | 27 | 42 | 35 | 31 | 19 | 12 | 1 | 2 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **7** |  | 5 | 5 | 7 | 15 | 15 | 22 | 15 | 5 | 14 | 3 | 3 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **8** |  | 4 | 7 | 5 | 6 | 12 | 10 | 11 | 7 | 9 | 6 | 5 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **9** |  | 2 | 0 | 3 | 4 | 5 | 3 | 5 | 4 | 7 | 3 | 0 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **10** |  | 0 | 2 | 2 | 0 | 0 | 3 | 4 | 1 | 3 | 6 | 6 |

#### **Table 3** Consistency (%) of anatomical distribution according to number of sites with pain in past month at follow-up and at baseline

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Number of anatomical sites with pain at baseline** |  | **Number of anatomical sites with pain in past month at follow-up** | | | | | | | | |
|  | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
|  |  |  |  |  |  |  |  |  |  |  |
| **1** |  | 55.4 | 66.9 | 76.8 | 78.4 | 90.9 | 100.0 | 78.6 | 80.0 | 100.0 |
|  |  |  |  |  |  |  |  |  |  |  |
| **2** |  | 62.3 | 62.4 | 70.2 | 81.3 | 81.7 | 91.3 | 100.0 | 100.0 | 100.0 |
|  |  |  |  |  |  |  |  |  |  |  |
| **3** |  | 65.6 | 72.1 | 69.5 | 80.7 | 86.8 | 83.3 | 90.0 | 91.7 | 100.0 |
|  |  |  |  |  |  |  |  |  |  |  |
| **4** |  | 69.0 | 76.1 | 75.2 | 76.3 | 76.4 | 84.5 | 84.2 | 84.4 | 100.0 |
|  |  |  |  |  |  |  |  |  |  |  |
| **5** |  | 63.2 | 81.3 | 84.0 | 77.8 | 79.3 | 81.3 | 81.0 | 75.0 | 100.0 |
|  |  |  |  |  |  |  |  |  |  |  |
| **6** |  | 76.5 | 78.8 | 84.0 | 86.9 | 78.6 | 68.5 | 70.2 | 50.0 | 100.0 |
|  |  |  |  |  |  |  |  |  |  |  |
| **7** |  | 80.0 | 92.9 | 97.8 | 88.9 | 80.3 | 73.3 | 66.7 | 60.7 | 33.3 |
|  |  |  |  |  |  |  |  |  |  |  |
| **8** |  | 85.7 | 100.0 | 100.0 | 87.5 | 80.0 | 68.2 | 71.4 | 66.7 | 33.3 |
|  |  |  |  |  |  |  |  |  |  |  |
| **9** |  |  | 66.7 | 100.0 | 60.0 | 100.0 | 60.0 | 25.0 | 71.4 | 0.0 |

#### **Table 4** Risk factors at baseline for major changes in the number of anatomical sites with pain at the end of follow-up

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Risk factor** |  | **Change from baseline to follow-up in number of sites with pain in past month** | | | | | | | | |
|  |  | **-2 to +2** |  | **Improvement**  **(change ≤ -3)** | | |  | **Deterioration**  **(change ≥ +3)** | | |
|  |  | **N** |  | **N** | **ORa** | **(95%CI)** |  | **N** | **ORa** | **(95%CI)** |
| **Sex** |  |  |  |  |  |  |  |  |  |  |
| Male |  | 2,724 |  | 131 | 1 |  |  | 200 | 1 |  |
| Female |  | 4,914 |  | 406 | 0.8 | (0.6,1.1) |  | 552 | 1.4 | (1.1,1.8) |
| **Age (years)** |  |  |  |  |  |  |  |  |  |  |
| 20-29 |  | 1,797 |  | 102 | 1 |  |  | 154 | 1 |  |
| 30-39 |  | 2,463 |  | 170 | 0.9 | (0.6,1.2) |  | 253 | 1.3 | (1.0,1.6) |
| 40-49 |  | 2,193 |  | 167 | 0.6 | (0.5,0.9) |  | 204 | 1.3 | (1.0,1.6) |
| 50-59 |  | 1,185 |  | 98 | 0.5 | (0.4,0.8) |  | 141 | 1.7 | (1.3,2.2) |
| **Age finished full-time education (years)** | | |  |  |  |  |  |  |  |  |
| ≥20 |  | 4,675 |  | 307 | 1 |  |  | 431 | 1 |  |
| 17-19 |  | 1,960 |  | 134 | 1.0 | (0.7,1.3) |  | 191 | 1.1 | (0.9,1.4) |
| 14-16 |  | 729 |  | 48 | 0.9 | (0.6,1.3) |  | 74 | 1.2 | (0.9,1.6) |
| <14 |  | 243 |  | 46 | 1.4 | (0.8,2.4) |  | 56 | 1.8 | (1.2,2.8) |
| Unknown |  | 31 |  | 2 |  |  |  | 0 |  |  |
| **Smoking status** |  |  |  |  |  |  |  |  |  |  |
| Never smoked |  | 4,858 |  | 374 |  |  |  | 519 |  |  |
| Ex-smoker |  | 1,113 |  | 51 | 0.6 | (0.4,0.9) |  | 108 | 1.2 | (1.0,1.5) |
| Current smoker |  | 1,650 |  | 111 | 1.1 | (0.8,1.5) |  | 123 | 0.9 | (0.7,1.2) |
| Missing |  | 17 |  | 1 |  |  |  | 2 |  |  |
| **Number of distressing somatic symptoms in past week** | | | | | |  |  |  |  |  |
| 0 |  | 4,719 |  | 222 | 1 |  |  | 409 | 1 |  |
| 1 |  | 1,631 |  | 118 | 0.6 | (0.5,0.9) |  | 201 | 1.4 | (1.2,1.7) |
| 2+ |  | 1,254 |  | 191 | 0.7 | (0.5,0.9) |  | 136 | 1.2 | (1.0,1.6) |
| Missing |  | 34 |  | 6 |  |  |  | 6 |  |  |
| **Mental health** |  |  |  |  |  |  |  |  |  |  |
| Good |  | 3,081 |  | 179 | 1 |  |  | 289 | 1 |  |
| Intermediate |  | 2,313 |  | 164 | 0.9 | (0.7,1.2) |  | 221 | 1.2 | (1.0,1.4) |
| Poor |  | 2,216 |  | 192 | 0.7 | (0.5,1.0) |  | 240 | 1.3 | (1.1,1.6) |
| Missing |  | 28 |  | 2 |  |  |  | 2 |  |  |
| **Number of physically loading activities** | | |  |  |  |  |  |  |  |  |
| 0 |  | 1,105 |  | 44 | 1 |  |  | 73 | 1 |  |
| 1 |  | 1,243 |  | 60 | 0.8 | (0.5,1.3) |  | 84 | 1.0 | (0.7,1.5) |
| 2 |  | 1,980 |  | 129 | 0.5 | (0.3,0.9) |  | 205 | 1.6 | (1.1,2.1) |
| 3 |  | 1,783 |  | 135 | 0.6 | (0.4,1.0) |  | 205 | 1.7 | (1.2,2.4) |
| 4 |  | 1,034 |  | 109 | 0.7 | (0.4,1.1) |  | 132 | 1.9 | (1.3,2.7) |
| 5 |  | 493 |  | 60 | 0.7 | (0.4,1.3) |  | 53 | 1.8 | (1.1,2.7) |
| **Psychosocial aspects of work** | | |  |  |  |  |  |  |  |  |
| Work ≥50 hours per week |  | 1,778 |  | 97 | 1.2 | (0.9,1.7) |  | 143 | 1.0 | (0.8,1.3) |
| Time pressure at work |  | 5,681 |  | 425 | 1.0 | (0.8,1.4) |  | 562 | 1.1 | (0.9,1.4) |
| Lack of support at work |  | 1,925 |  | 168 | 0.8 | (0.6,1.0) |  | 218 | 1.1 | (0.9,1.3) |
| Job dissatisfaction |  | 1,491 |  | 104 | 0.9 | (0.7,1.2) |  | 138 | 1.0 | (0.8,1.3) |
| **Adverse beliefs about musculoskeletal pain** | | | | |  |  |  |  |  |  |
| Work-relatedness |  | 2,961 |  | 292 | 1.1 | (0.9,1.4) |  | 350 | 1.3 | (1.1,1.5) |
| Physical activity |  | 1,689 |  | 116 | 1.1 | (0.8,1.4) |  | 179 | 0.9 | (0.7,1.1) |

#### 

aOdds ratios derived from a single, random intercept, logistic regression model for each outcome, with adjustment also for then number of anatomical sites affected at baseline

#### **Figure 1** Distribution of participants by change from baseline to follow-up in the number of painful sites in the past month