Received: 12 July 2021 | Revised: 31 March 2022 | Accepted: 14 May 2022

DOI: 10.1002/ejp.1978

EJP European Journal of Pain

ORIGINAL ARTICLE

Patterns of change of multisite pain over 1 year of follow-up and related risk factors

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Funding information
Georgia Ntani, David Coggon and Karen Walker-Bone were supported by funding from the Medical Research Council and Versus Arthritis. Monash University funded data collection in Australia. NHMRC (Australia) supported Helen Kelsall through a fellowship. Data collection in Central America and Colombia was supported by a research training grant to Southwest Center for Occupational and Environmental Health at the University of Texas Health Science Center from the NIH Fogarty International Center. The Deputy for Training and Research, Shahroud University of Medical Sciences provided financial support for data collection in Iran. Institute of Health Carlos III (ISCIII) funded data collection in Spain. The Health Research Council of New Zealand funded data collection in New Zealand. We are particularly grateful to the Colt Foundation, which funded data collection in Brazil, Ecuador, Costa Rica, Nicaragua, United Kingdom, Greece, Estonia, Lebanon, Pakistan and South Africa.

Abstract

Background: Multisite musculoskeletal pain is common and disabling. This study aimed to prospectively investigate the 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: Among 8927 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 predictives were as follows: older age, somatizing 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 sensitization mechanisms, rather than localized risk factors, among working adults.

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 localized stressors specific to only one or two anatomical sites.

1 | INTRODUCTION

Musculoskeletal pain frequently affects multiple anatomical sites in the same individual (Carnes et al., 2007; Hartvigsen, Davidsen, et al., 2013; Hartvigsen, Natvig, & Ferreira, 2013), impacting importantly on daily functioning (Kamaleri et al., 2008a; Saastamoinen et al., 2006), work ability, healthcare seeking (Mose et al., 2021) and sickness absence (Neupane et al., 2015). We have previously shown large international differences in the prevalence of multi-site pain among working populations (Coggon et al., 2013), 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 2 years or longer (Christensen et al., 2017; Kamaleri et al., 2008b). 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 somatizing tendency (Christensen et al., 2017; Coggon et al., 2013; Croft et al., 1993; Gupta et al., 2007) and poorer mental health (Christensen et al., 2017; Croft et al., 1993; Haukka et al., 2011), may act through central mechanisms of pain perception. Others, such as occupational tasks that mechanically load the musculoskeletal system (Coggon et al., 2013; Neupane et al., 2016), 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 was 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.

2 | METHODS

The methods of the CUPID study have been described in detail elsewhere (Coggon et al., 2012). 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 1 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 (categorized as never smoked, ex-smoker or current smoker); somatizing 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.

Somatizing tendency was assessed using questions from the Brief Symptom Inventory (Derogatis & Melisaratos, 1983), 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 Jr. & Sherbourne, 1992), 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 h in total with the hands above shoulder height; repeated bending and straightening of the elbow for >1 h in total; repeated movements of the wrist or fingers for >4 h in total; and kneeling or squatting for >1 h 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.

2.1 | Statistical analysis

We initially described the distribution of participants according to the 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 the report of pain at baseline and at follow-up, using the kappa statistic.

We then assessed the degree to which the 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 (N_b), follow-up (N_f) and both time points (N_{bf}). We first calculated the minimum and maximum number of sites that could be painful at both time points, given the values for (N_b) and (N_f), by applying the formulae:

$$\text{Minimum possible concordance} = \max\left[\left(N_b + N_f - 10\right), 0\right].$$

$$\text{Maximum possible concordance} = \min\left[N_b, N_f\right].$$

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:

$$\text{Consistency} = \left(N_{bf} - \max\left[\left(N_b + N_f - 10\right), 0\right]\right) * 100 / \left(\min\left[N_b, N_f\right] - \max\left[\left(N_b + N_f - 10\right), 0\right]\right).$$

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 summarized 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).

3 | 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, 9305 (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). Among those who followed up, 8927 (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 1-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).

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

	Pain in past month at baseline and at follow-up				
Anatomical site	**−/−**	**+/−**	**−/+**	**+/+**	**Kappa**
Low back	4200	1174	1483	2070	0.370
Neck	4744	973	1394	1816	0.407
Right shoulder	6223	859	1028	817	0.333
Left shoulder	6838	743	850	496	0.280
Right elbow	7849	375	483	220	0.288
Left elbow	8218	287	316	106	0.225
Right wrist/hand	6664	726	809	728	0.384
Left wrist/hand	7394	514	637	382	0.327
Right knee	6716	705	835	671	0.363
Left knee	6887	690	757	593	0.355

Note. −/− 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.

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 ($N = 1782$) reported no painful sites either at baseline or follow-up, while 16% ($N = 1461$) reported three or more painful sites at both time points. Just over 15% ($N = 1420$) 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 ($N = 3234$ including $N = 1519$ with no affected sites at baseline) than a reduction ($N = 2491$ 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 summarizes 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 1414 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

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	1782	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

−2 and +2, including over one-third ($N = 3202$) with no change at all (Figure 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, somatizing 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 the effect being what one would expect (e.g. 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).

4 | 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

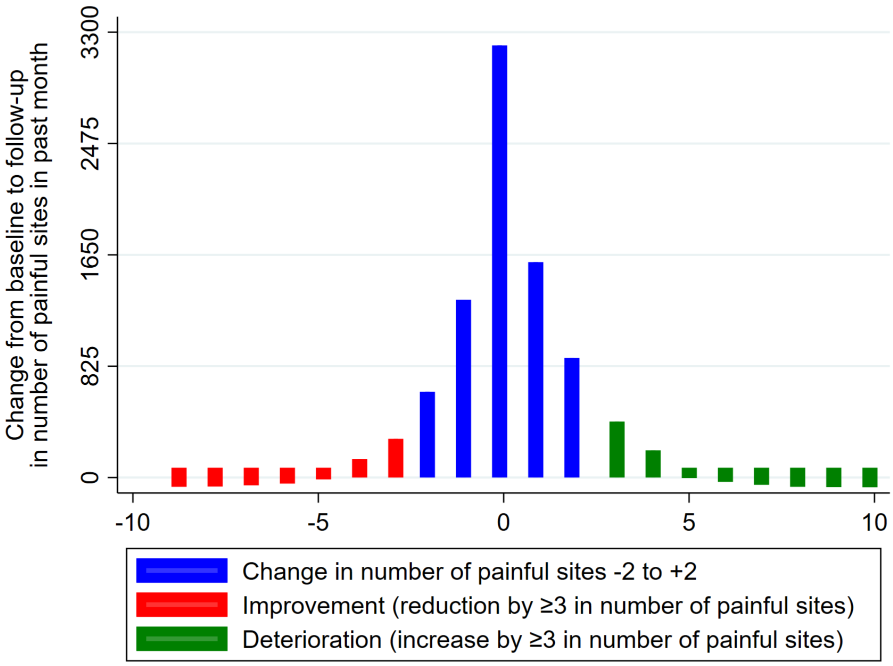

FIGURE 1 Distribution of participants by change from baseline to follow-up in the number of painful sites in the past month

of sites reported as painful often changed. Risk factors for deterioration in the extent of pain included older age, somatizing 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 10 anatomical sites and a wide range of potential risk factors were collected through standardized questions, many of which were taken, or modified, from established and widely used instruments (Coggon et al., 2012).

There are, however, several potential limitations that need to be considered in interpretation of the findings. First, 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.

Second, 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). 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

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

	Change from baseline to follow-up in number of sites with pain in past month						
	-2 to +2	Improvement (change ≤−3)			Deterioration (change ≥+3)		
Risk factor	***N***	***N***	**OR[a]**	**(95% CI)**	***N***	**OR[a]**	**(95% CI)**
Sex							
Male	2724	131	1		200	1	
Female	4914	406	0.8	(0.6, 1.1)	552	1.4	(1.1, 1.8)
Age (years)							
20–29	1797	102	1		154	1	
30–39	2463	170	0.9	(0.6, 1.2)	253	1.3	(1.0, 1.6)
40–49	2193	167	0.6	(0.5, 0.9)	204	1.3	(1.0, 1.6)
50–59	1185	98	0.5	(0.4, 0.8)	141	1.7	(1.3, 2.2)
Age finished full-time education (years)							
≥20	4675	307	1		431	1	
17–19	1960	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	4858	374			519		
Ex-smoker	1113	51	0.6	(0.4, 0.9)	108	1.2	(1.0, 1.5)
Current smoker	1650	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	4719	222	1		409	1	
1	1631	118	0.6	(0.5, 0.9)	201	1.4	(1.2, 1.7)
2+	1254	191	0.7	(0.5, 0.9)	136	1.2	(1.0, 1.6)
Missing	34	6			6		
Mental health							
Good	3081	179	1		289	1	
Intermediate	2313	164	0.9	(0.7, 1.2)	221	1.2	(1.0, 1.4)
Poor	2216	192	0.7	(0.5, 1.0)	240	1.3	(1.1, 1.6)
Missing	28	2			2		
Number of physically loading activities							
0	1105	44	1		73	1	
1	1243	60	0.8	(0.5, 1.3)	84	1.0	(0.7, 1.5)
2	1980	129	0.5	(0.3, 0.9)	205	1.6	(1.1, 2.1)
3	1783	135	0.6	(0.4, 1.0)	205	1.7	(1.2, 2.4)
4	1034	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 h per week	1778	97	1.2	(0.9, 1.7)	143	1.0	(0.8, 1.3)
Time pressure at work	5681	425	1.0	(0.8, 1.4)	562	1.1	(0.9, 1.4)
Lack of support at work	1925	168	0.8	(0.6, 1.0)	218	1.1	(0.9, 1.3)
Job dissatisfaction	1491	104	0.9	(0.7, 1.2)	138	1.0	(0.8, 1.3)

(Continues)

TABLE 4 (Continued)

Risk factor	Change from baseline to follow-up in number of sites with pain in past month -2 to +2 *N*	Improvement (change ≤−3) *N*	OR[a]	(95% CI)	Deterioration (change ≥+3) *N*	OR[a]	(95% CI)
Adverse beliefs about musculoskeletal pain							
Work-relatedness	2961	292	1.1	(0.9, 1.4)	350	1.3	(1.1, 1.5)
Physical activity	1689	116	1.1	(0.8, 1.4)	179	0.9	(0.7, 1.1)

[a]Odds ratios derived from a single, random intercept, logistic regression model for each outcome, with adjustment also for the number of anatomical sites affected at baseline.

patterns of reported pain at 10 anatomical sites in six birth cohorts (Kamaleri et al., 2008b). 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 2-year interval, the number of painful sites was the same within ±1 in 79.3% of participants (Christensen et al., 2017).

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 among >12,000 people with mean age 57.2 years (Gummesson et al., 2006). 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, for example 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), and shoulder-neck (Andersson et al., 1996) and for chronic widespread pain (McBeth et al., 2001). 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 & Falah-Hassani, 2017) 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; Itz et al., 2013).

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 somatize 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 the 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 (Coggon et al., 2013), and with findings from other cross-sectional and longitudinal studies of risk factors for multisite or widespread pain (Cho et al., 2012; Christensen et al., 2017; Croft et al., 1993; Gupta et al., 2007; Haukka et al., 2011; Kamaleri, Natvig, Ihlebaek, & Bruusgaard, 2008; Neupane et al., 2016). In particular, multisite pain has been linked to female sex (Cho et al., 2012; Coggon et al., 2013; Kamaleri et al., 2008a; Neupane et al., 2016), older age (Cho et al., 2012; Coggon et al., 2013; Neupane et al., 2016), other somatic symptoms (Christensen et al., 2017; Coggon et al., 2013; Croft et al., 1993; Gupta et al., 2007), poor mental health (Christensen et al., 2017; Croft et al., 1993; Haukka et al., 2011) and physically demanding work (Coggon et al., 2013; Neupane et al., 2016). 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 (Coggon et al., 2013), job dissatisfaction (Neupane et al., 2016; Solidaki et al., 2010) and lack of employer or co-worker support (Coggon et al., 2013; Haukka et al., 2011; Solidaki et al., 2010). 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 affect 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 localized stressors specific to only one or two anatomical sites. There is no obvious reason why the 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 an 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 the local mechanical loading of tissues when developing strategies for the prevention of musculoskeletal pain in working populations.

AUTHORS' CONTRIBUTIONS

David Coggon initiated and coordinated the CUPID study, and led data collection in the United Kingdom; 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 United Kingdom; 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. In addition, all authors provided feedback on the initial draft manuscript, and agreed the final changes.

ACKNOWLEDGEMENTS

We thank the following who in various ways contributed to data collection for the CUPID study: Leila M M Sarquis and Maria H Marziale (Brazil); Raul Harari, Rocio Freire, Natalia Harari, Pietro Muñoz, Patricio Oyos, Gonzalo Albuja, María Belduma and Francisco Lara (Ecuador); Leonardo A Quintana and Magda V Monroy (Colombia); David Gimeno (Costa Rica and Nicaragua); Eduardo J. Salazar Vega, Patricia Monge, Melania Chaverri and Freddy Brenes (Costa Rica); Aurora Aragón, Alberto Berríos, Samaria Balladares, Martha Martínez and Alfredo José Jirón (Nicaragua); Keith T Palmer and E Clare Harris (UK); Sergio Vargas-Prada, J Miguel Martinez, George Delclos, Fernando G Benavides, Catalina Torres, Ben and Marie Carmen Coggon, Cynthia Alcantara, Xavier Orpella, Josep Anton Gonzalez, Joan Bas, Pilar Peña, Elena Brunat, Vicente San José, Anna Sala March, Anna Marquez, Josefina Lorente, Cristina Oliva, Montse Vergara and Eduard Gaynés (Spain); Marco M Ferrario, Michele Carugno, Angela C Pesatori, Natale Battevi, Lorenzo Bordini, Marco Conti, Luciano Riboldi and Paul Maurice Conway (Italy); Manolis Kogevinas, Leda Chatzi, Eleni Solidaki and Panos Bitsios (Greece); Kristel Oha, Tiina Freimann and Tuuli Sirk (Estonia); Ali Sadeghian (Iran); Asad Ali Khan, Masood Kadir and Khalil Qureshi (Pakistan); Sudath SP Warnakulasuriya, Nalini Sathiakumar and Roshini J Peiris-John (Sri Lanka); Noriko Yoshimura, Masami Hirai, Tatsuya Isomura, Norimasa Kikuchi, Akiko Ishizuka and Takayuki Sawada (Japan); Malcolm Sim, Victor C W Hoe and Donna M Urquhart (Australia); Sarah Derrett, David McBride, Peter Herbison and Andrew Grey (New Zealand). Ken Cox collated the dataset and prepared files for statistical analysis. We thank all of the organizations that allowed us to approach their employees; and all of the workers who kindly participated in the study.

CONFLICT OF INTEREST

None declared.

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How to cite this article: Ntani, G., Coggon, D., Felli, V. E., Harari, F., Barrero, L. H., Felknor, S. A., Rojas, M., Serra, C., Bonzini, M., Merisalu, E., Habib, R. R., Sadeghian, F., Wickremasinghe, A. R., Matsudaira, K., Nyantumbu-Mkhize, B., Kelsall, H. L., Harcombe, H., & Walker-Bone, K. (2022). Patterns of change of multisite pain over 1 year of follow-up and related risk factors. *European Journal of Pain*, *26*, 1499–1509. https://doi.org/10.1002/ejp.1978