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Risk factors for new-onset low back pain amongst cohorts of newly employed workers

E. F. Harkness[1], G. J. Macfarlane[1,2], E. S. Nahit[1,2], A. J. Silman[1] and J. McBeth[1]

Objectives. **To test the hypothesis that work-related mechanical, psychosocial and physical environment factors would predict new-onset low back pain (LBP) in newly employed workers.**

Methods. **A total of 1186 newly employed workers were recruited from a variety of occupational settings. Those who were free from LBP at baseline were identified. Subjects were followed up at 12 and 24 months. Work-related mechanical, psychosocial and physical environment exposures were measured. Generalized estimating equations were used to assess predictors of new-onset LBP.**

Results. **New-onset LBP was reported by 119 (19%) and 81 (19%) subjects at 12 and 24 months, respectively. Several work-related mechanical exposures predicted new-onset LBP including lifting heavy weights with one or two hands, lifting heavy weights at or above shoulder level, pulling heavy weights, kneeling or squatting for 15 min or longer. Of the psychosocial factors examined, stressful and monotonous work significantly predicted symptom onset. In addition, hot working conditions and pain at other sites also predicted new-onset LBP. On multivariate analysis these risks were only moderately attenuated but the 95% confidence intervals excluded unity only for the latter, non-mechanical, exposures.**

Conclusion. **In this cohort of newly employed workers, from a range of occupations, several aspects of the work-place environment, other than mechanical factors, were important in predicting new-onset LBP. These results emphasize that interventions aimed at reducing the occurrence of LBP are likely to be most successful if they intervene across these domains.**

KEY WORDS: Low back pain, Work-related factors, Healthy worker effect, New workers.

The consequences of LBP are far reaching with sufferers experiencing high levels of disability, reduced quality of life and physical and psychological distress. These factors are associated with increased absence from work, lost productivity and resulting economic costs. Within the UK the economic burden of LBP was estimated to be in the region of £12 billion in 1998 [1]. Indirect costs, due to lost productivity and informal care costs, by far comprise the largest proportion of this cost [1].

Both individual psychosocial and lifestyle factors, and work-place exposures have been implicated in the onset of symptoms [2, 3]. Typically, studies investigating occupational risk factors for LBP have tended to focus on work-related mechanical risk factors with many using job title as a proxy measure of physical load. On the other hand, quantitative exposure information provides more reliable information about actual activities performed. Including only those studies with quantitative exposure information, Burdorf and Sorock [4] consistently reported increased associations between mechanical factors, such as manual handling, handling heavy loads and frequent bending and twisting, and the risk of LBP.

More recently, work-related psychosocial factors have also been considered as risk factors for LBP [5–8]. It has

[1]Arthritis Research Campaign Epidemiology Unit and [2]Unit of Chronic Disease Epidemiology, Medical School, University of Manchester, Oxford Road, Manchester, M13 9PT, UK.

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Correspondence to: E. F. Harkness, ARC Epidemiology Unit, The Medical School, The University of Manchester, Oxford Road, Manchester, M13 9PT, UK. E-mail: moeyjefh@fs1.ser.man.ac.uk

been hypothesized that such factors may be related to increased stress and subsequent adverse health outcomes as a result of various organizational and social factors of the work place [9]. More specifically, those with little control over their work, high demands from the work place and low social support from colleagues or supervisors are believed to be at an increased risk of developing poor health outcomes.

However, despite the large number of published studies, methodological issues have impaired the interpretation of these findings. First, many studies investigating work-related exposures as risk factors for LBP have tended to focus on individual occupational groups and it is often difficult to generalize the results to different occupational groups.

Second, many of the studies have been cross-sectional in design and may be affected by recall bias. The true relationship between exposures and LBP can only be disentangled in a prospective study that collects details on exposure prior to the occurrence of the pain. Occupational studies of established work forces are likely to be influenced by the 'healthy worker effect' since they do not provide the opportunity to ascertain those individuals who have left the work place or who have chosen less physically demanding jobs as a result of their LBP. However, the healthy worker effect may still have an impact even in prospective studies, where individuals with pre-existing LBP may choose less active occupations as a result of their pain. A further advantage of prospective studies is that the temporal relationship between exposure and outcome can be established.

We therefore conducted a prospective cohort study of newly employed workers from a range of occupational settings. The aim of this study was to identify work-related mechanical and psychosocial risk factors and physical working conditions, and to assess the relative importance of these factors in predicting new-onset LBP.

Subjects and methods

Design

We conducted a prospective cohort study of newly employed workers from 12 occupational groups. Exposure was assessed at baseline and 12 months in those free from LBP. Subjects were followed-up to determine those who developed new-onset LBP at 12 and 24 months after baseline (Fig. 1).

Subjects

Study subjects were 1186 newly employed workers from 12 diverse occupational groups, the majority of whom were taking up full-time employment for the first time. Subjects were recruited from three sources: service organizations recruiting new trainees, e.g. police and army officers; newly opened work places, e.g. a supermarket and postal distribution centre; and final year students of vocational courses, e.g. nurses, dentists and podiatry students. Full details on the sources of recruitment have been described elsewhere [10] and are given in the Appendix.

A conservative 1-month period prevalence estimate of 20% for low back pain was used to determine sample size [11]. Assuming the prevalence of adverse psychosocial factors in pain-free subjects was 10%, it was estimated that 1000 subjects were required to have 80% power of detecting a doubling of risk associated with such a factor (significance level $P = 0.05$) [10].

Baseline exposures

Information was collected by means of a self-administered questionnaire. For the majority of individuals the questionnaire was distributed and completed during organized sessions in the work place. The remainder received a postal questionnaire, with up to two reminders being sent to non-responders. Information was collected on four individual domains by means of a self-administered questionnaire as detailed below.

(1) Mechanical factors: work-related manual handling activities. Questions on manual handling activities were taken from a previously validated questionnaire [12]. Direct observations, which were taken as the standard, were compared with self-administered questionnaires. The accuracy of self-reported

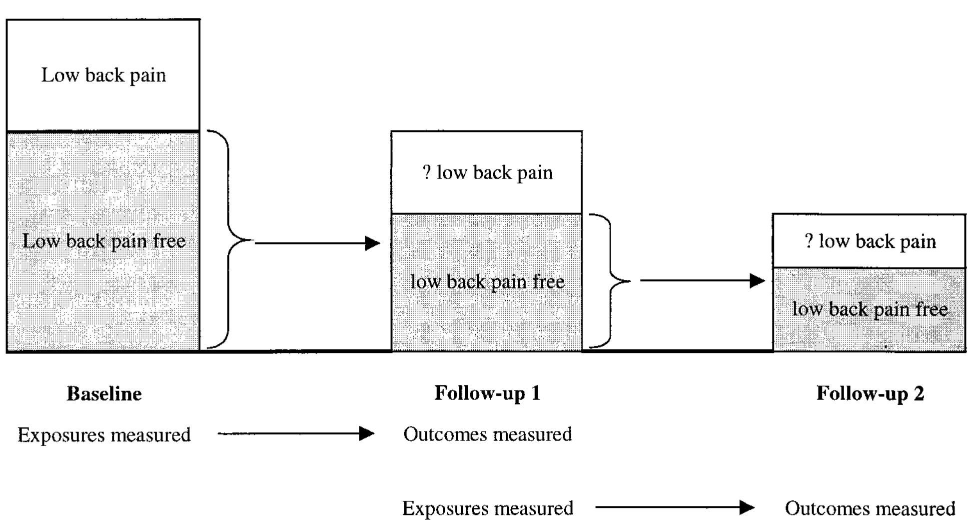

FIG. 1. New onset of low back pain from baseline to follow-up.

demands was assessed by sensitivity and specificity analysis. The majority of activities had good sensitivity (at least 60%) and specificity (above 70%) [12]. Individuals were asked about six manual handling activities performed during the last working day: carrying weights on one shoulder, lifting or carrying weights with one hand, lifting weights with two hands, pushing weights, pulling weights and lifting weights at or above shoulder level. For all activities individuals were asked how long they performed each task and what weights were involved (using a visual guide to help estimate weights).

Mechanical factors: work-related postures. Questions on posture were based on the same validated questionnaire as that used for mechanical exposures [12]. Sensitivity and specificity was above 70% for all posture variables. Individuals were asked about posture during the last working day (sitting, standing, kneeling, squatting, bending forwards, stretching below knee level, working with hands at or above shoulder level) and how much of their time was spent in each position.

(2) Work-related psychosocial factors. Questions on psychosocial exposures were based on the Demand, Support and Control model proposed by Karasek [9]. Individuals were asked about the following items in relation to their current job: job satisfaction, feeling that their work was monotonous or boring, work pace, stress/worry, control over work, ability to learn new things and support from work colleagues and supervisors. These questions were originally used by the Medical Research Council in the West of Scotland Twenty-07 Study of Health in the Community [13]. These questions have been used in studies of low back pain in the general population [14] and to assess work-related risk factors for shoulder pain [15]. In addition, the General Health Questionnaire (GHQ) was included as a measure of individual psychological distress [16].

(3) Physical environment. Individuals were asked whether they worked in hot, cold or damp conditions during their last working day and if so, for how long.

(4) Other pain. Individuals were asked whether they had experienced any pain lasting 24 h or longer in the past month. If they responded yes, they were asked to indicate the site of any pain on a line drawing of the body. This was included as a marker for new pain onset as opposed to a risk factor itself.

LBP classification. The same approach was used at baseline and both follow-ups. Subjects were asked 'Thinking back over the past month, have you had any ache or pain which lasted for one day or longer?' If yes, subjects were asked to indicate the site of any pain on a line drawing of the body. LBP was defined as pain localized between the 12th rib and the gluteal folds lasting for 24 h or longer in the past month (Fig. 2). On the basis of their responses subjects were dichotomized into those with and without LBP.

Follow-up

Those subjects free from LBP at baseline were eligible for follow up at 12 months, and those free from LBP at baseline and 12 months were eligible for follow-up at 24 months. At follow-up the same approach was used for exposure assessment. In addition, individuals were also asked to record any changes in their job or job-related activities owing to aches or pains.

Analysis

All the exposure variables were divided into categories. For mechanical factors the referent group were those who did not perform the specific manual handling activities, with those who performed these activities dichotomized into two equal groups based on the distribution of the weights lifted. In the same way, those who did not report potentially harmful work-related postures were the referent group with those who adopted these postures dichotomized into two equal groups based on the time spent in each position. The GHQ scores were categorized into those with minimal distress (score of 0) with the remainder being divided into two equal groups, based on the score distribution. All other exposure variables were dichotomized.

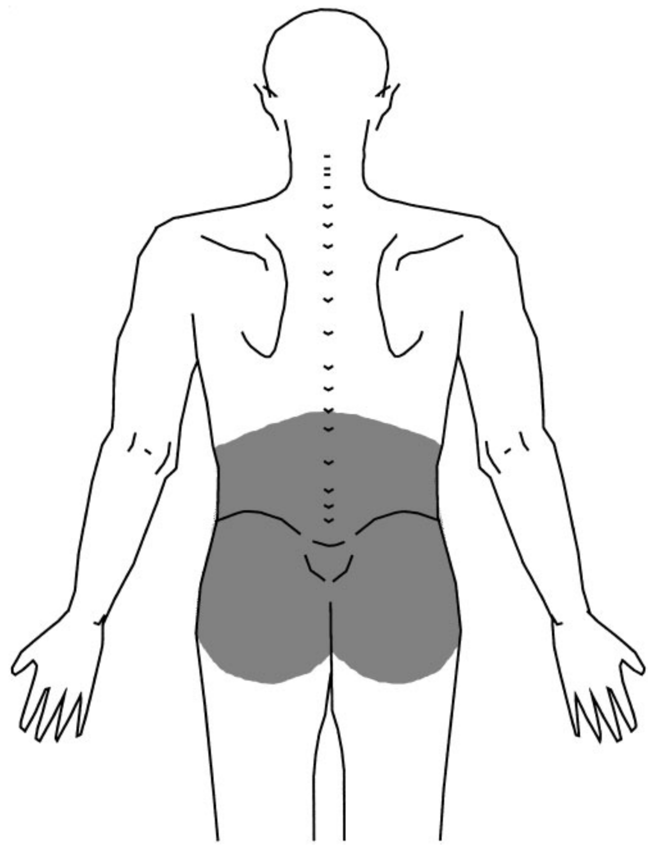

FIG. 2. Pre-shaded mannikin for low back pain.

Owing to the fact that we had repeated measures at baseline, 12 and 24 months, generalized estimating equations (GEEs) [17] were used to examine predictors of new-onset LBP at 12 and 24 months (Fig. 1). GEEs take account of the correlation within individuals measured at multiple time points. All analyses were adjusted for age, gender and occupational group. Results are expressed as odds ratios (OR) with 95% confidence intervals (CI). The analysis was conducted as follows.

Univariate associations, adjusted for age, gender and occupational group, were assessed for each of the individual exposure variables.

Separate domain-specific multivariate models were formed for each of the main groups of exposure variables. Where two variables were strongly correlated, the variable with the strongest or most stable estimate from the univariate analysis was included in the domain-specific model.

Those variables that were found to have an increased (OR ≥ 1.5), decreased (OR ≤ 0.67) or statistically significant association with new-onset LBP were then entered into a final multivariate model constructed across all the exposure domains to identify the smallest number of predictive factors. All variables in the final model were examined for interactions within each domain and by follow-up period.

All analyses were conducted using the statistical package Stata (version 7) [18].

Results

The prevalence of new-onset LBP

A total of 1081 subjects were recruited at baseline (response rate 91%) of whom 275 (25%) reported LBP. Of the 788 subjects eligible for follow-up, men comprised a larger proportion of the study cohort (64% males) and the median age of those eligible for follow-up was 23 yr (interquartile range 21–28 yr). At 12 months, 625 (79%) of the 788 eligible subjects responded and new-onset LBP was reported by 119 (19%) subjects. Of the 501 free from LBP at 12 months, 81 (19%) of the 430 responders reported LBP at 24 months (Fig. 3).

Prevalence of new-onset LBP varied widely by occupational group. At 12 months the prevalence was lowest in army officers (5%) and highest in podiatrists (52%). At 24 months prevalence rates varied from 10% in forestry workers and army officers to 29% in podiatrists.

Univariate analysis

In the univariate analysis of manual handling activities (Table 1), individuals who lifted more than 24 lbs with two hands, those who lifted weights of more than 23 lbs at or above shoulder level and those who pulled weights of more than 56 lbs all had approximately double the odds of reporting new-onset LBP when compared with those who did not perform these activities. Of the postural factors examined (Table 2), those individuals whose jobs involved kneeling (OR 2.1, 95% CI 1.3–3.3) or squatting (OR 1.8, 95% CI 1.1–3.1) for 15 min or more were significantly more likely to report new-onset LBP at follow-up.

A number of work-related psychosocial factors predicted new-onset LBP (Table 3). The highest risk was associated with monotonous work, with those subjects who reported their work as monotonous or boring at least half of the time experiencing an almost double risk

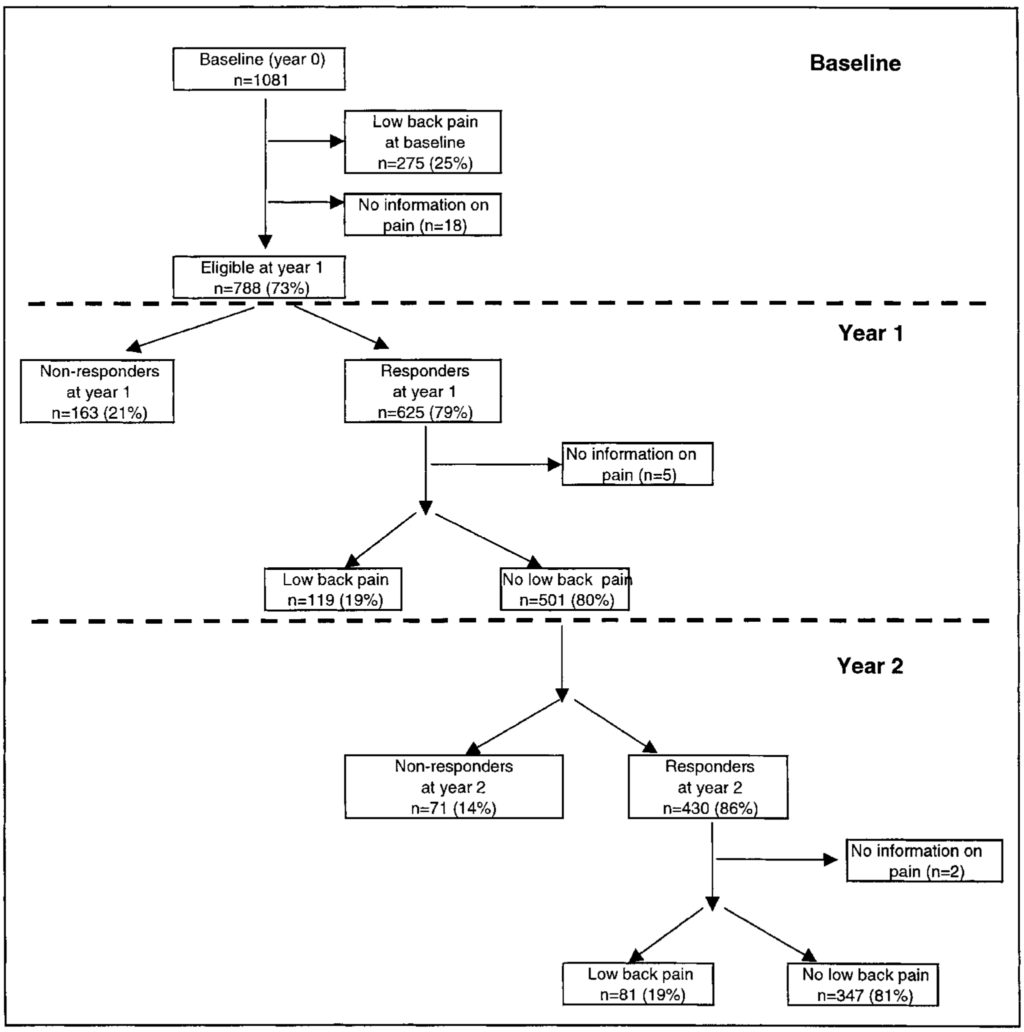

FIG. 3. Flow of subjects from the new workers study.

TABLE 1. Work-related mechanical risk factors and new onset low back pain

Exposure	Low back pain		Univariate associations[a]		Multivariate associations[a,b]	
	No	Yes	OR	95% CI	OR	95% CI
Manual handling activities						
Lift or carry with one hand:						
Never	402	94	1	Referent	1	Referent
⩽15 lb	208	55	1.4	0.9–2.1	1.3	0.8–2.0
>15 lb	225	49	1.6	0.98–2.7	1.1	0.6–1.9
Lift or carry with two hands:						
Never	373	88	1	Referent	1	Referent
⩽24 lb	235	54	1.3	0.9–2.1	1.1	0.7–1.7
>24 lb	225	54	1.8	1.1–2.9	1.4	0.8–2.5
Carrying on one shoulder:						
Never	663	153	1	Referent	1	Referent
⩽30 lb	88	21	1.1	0.7–1.9	0.9	0.5–1.7
>30 lb	85	17	1.3	0.7–2.4	0.9	0.5–1.9
Lifting at or above shoulder level:						
Never	630	144	1	Referent	1	Referent
⩽23 lb	101	27	1.6	0.9–2.6	1.3	0.8–2.2
>23 lb	100	26	2.1	1.2–3.8	1.8	0.9–3.5
Pushing:						
Never	539	127	1	Referent	1	Referent
⩽65 lb	143	39	1.3	0.8–2.1	1.1	0.7–1.9
>65 lb	151	32	1.3	0.7–2.2	0.9	0.5–1.6
Pulling:						
Never	637	143	1	Referent	1	Referent
⩽56 lb	100	26	1.5	0.9–2.6	1.4	0.8–2.4
>56 lb	96	29	2.1	1.2–3.4	1.7	0.96–3.1

[a]Adjusted for gender, age group and occupation.
[b]Adjusted for all other manual handling activities.

TABLE 2. Work-related mechanical risk factors and new onset low back pain

Exposure	Low back pain		Univariate associations[a]		Multivariate associations[a,b]	
	No	Yes	OR	95% CI	OR	95% CI
Posture						
Sitting:						
Do not sit as part of job	265	57	1	Referent	1	Referent
<2 h	196	47	1.0	0.6–1.6	1.0	0.6–1.7
⩾2 h	377	94	0.9	0.6–1.4	1.0	0.6–1.7
Standing:						
Do not stand as part of job	76	18	1	Referent	1	Referent
<15 min	275	53	1.1	0.6–2.1	1.0	0.5–1.9
15 min- <2 h	254	69	1.6	0.8–2.9	1.4	0.7–2.7
⩾2 h	234	58	1.8	0.9–3.4	1.5	0.8–3.0
Kneeling:						
Never	513	107	1	Referent	1	Referent
<15 min	218	54	1.4	0.9–2.2	1.2	0.8–2.0
⩾15 min	108	38	2.1	1.3–3.3	1.7	1.0–2.9
Squatting:						
Never	500	116	1	Referent		
<15 min	237	53	1.1	0.7–1.7		
⩾15 min	88	29	1.8	1.1–3.1		
Bending:						
Never	434	84	1.0	Referent	1.0	Referent
<15 min	215	67	1.6	1.1–2.3	1.3	0.9–2.0
⩾15 min	181	47	1.3	0.8–1.9	1.0	0.6–1.5
Stretching below knee level:						
No	454	108	1	Referent	1	Referent
Yes	383	91	1.2	0.9–1.8	1.0	0.7–1.4
Working with hands above shoulder:						
Never	455	100	1	Referent	1	Referent
<15 min	230	60	1.6	1.1–2.4	1.4	0.9–2.2
⩾15 min	150	39	1.6	0.99–2.5	1.3	0.8–2.2

[a]Adjusted for gender, age group and occupation.
[b]Adjusted for all other postures.

TABLE 3. Work-related psychosocial risk factors and new onset low back pain

	Low back pain		Univariate associations[a]		Multivariate associations[a,b]	
Exposure	No	Yes	OR	95% CI	OR	95% CI
Job demand						
Stressful work:						
Never/occasionally	694	148	1	Referent	1	Referent
At least half of the time	142	52	1.6	1.1–2.4	1.5	0.9–2.4
Monotonous work:						
Never/occasionally	735	163	1	Referent	1	Referent
At least half of the time	98	36	1.9	1.2–3.1	1.8	1.1–3.0
Hectic work:						
Never/occasionally	600	139	1	Referent	1	Referent
At least half of the time	236	61	1.2	0.9–1.8	1.0	0.7–1.5
Job satisfaction						
Job satisfaction:						
Not dissatisfied	805	190	1	Referent	1	Referent
(Very)/dissatisfied	28	9	1.3	0.6–3.0	0.7	0.3–1.9
Social support						
Support from colleagues:						
Not dissatisfied	818	192	1	Referent	1	Referent
(Very)/dissatisfied	17	7	1.9	0.7–4.7	1.4	0.5–3.7
Control over work						
Control over own work:						
At least sometimes	762	189	1	Referent	1	Referent
(Very)/seldom	71	11	0.7	0.4–1.5	0.7	0.3–1.4
Learn new things:						
At least sometimes	794	188	1	Referent	1	Referent
(Very)/seldom	43	12	1.7	0.8–3.5	1.4	0.6–3.1
Individual distress (GHQ)						
GHQ total:						
0	520	114	1	Referent	1	Referent
1–2	197	42	1.0	0.7–1.5	0.9	0.6–1.4
⩾3	127	43	1.4	0.9–2.2	1.1	0.7–1.8

[a]Adjusted for gender, age group and occupation.
[b]Adjusted for all other psychosocial exposures.

TABLE 4. Work conditions and other pain as risk factors for new onset low back pain

	Low back pain		Univariate associations[a]		Multivariate associations[a,b]	
Exposure	No	Yes	OR	95% CI	OR	95% CI
Working conditions						
Work in hot conditions:						
No	642	137	1	Referent	1	Referent
Yes	196	60	1.8	1.2–2.7	1.9	1.3–2.9
Work in cold conditions:						
No	683	159	1	Referent	1	Referent
Yes	139	34	1.3	0.8–2.1	1.3	0.8–2.2
Work in damp conditions:						
No	618	152	1	Referent	1	Referent
Yes	184	35	1.0	0.6–1.6	0.8	0.5–1.4
Other pain						
(any other pain except low back):						
No	522	101	1	Referent		
Yes	326	99	1.7	1.2–2.4		

[a]Adjusted for gender, age group and occupation.
[b]Adjusted for all other working conditions.

of symptom onset. Subjects who reported their work to be stressful were also at an increased risk of reporting new symptom onset.

Of the other factors examined, working in hot conditions predicted new-onset LBP with almost twice the odds of those unexposed (Table 4). On further analysis we found that this association was statistically significant for shipbuilders who had an increased odds of 2.6 (95% CI 1.1–6.5) of developing new-onset LBP at follow-up. Finally, pain at any other regional site was also found to predict new-onset LBP at follow-up, with such individuals having a 70% increased risk of new-onset LBP.

Domain-specific models

On examination of the associations of new symptom onset within domain multivariate models, none of the manual handling activities remained statistically significant. However, lifting weights at or above shoulder level and pulling weights both had ORs above 1.5 and therefore met the inclusion criteria for the final multivariate model. Squatting was excluded from the postural model, since it was strongly correlated with kneeling ($r=0.61$) and was not as strongly related to LBP as kneeling in the univariate analysis. Kneeling for more than 15 min remained significant in the posture domain model. In the psychosocial model, monotonous work predicted new-onset LBP. Hot working conditions remained strongly predictive of new-onset LBP in the physical environment model.

Final multivariate model

Results from the final multivariate model, showing the relative contribution of work-related mechanical, psychosocial and physical working environment factors in symptom onset, are given in Table 5. Six factors remained important: lifting weights of more than 23 lb at or above shoulder level, pulling weights of more than 56 lb and kneeling for 15 min or longer were all associated with modest, though non-significant, increased odds of developing new LBP. Pain at other sites was associated with a significantly increased risk of new-onset LBP. However, the greatest risk was conferred by monotonous work and hot working conditions, which were associated with an 80 and 70% increased risk of developing new-onset LBP, respectively. None of the interactions within domains and by follow-up period met our inclusion criteria.

For those factors included in the final model we assessed the prevalence of new-onset LBP according to the number of factors reported by individuals. The prevalence rate of new LBP increased from 15% in those exposed to none of these factors to 34% in those exposed to four or more factors.

Table 5. Final model predictors for new onset low back pain[a] multivariate associations

Exposure	OR	95% CI
Mechanical load		
Lifting at or above shoulder level:		
Never	1	Referent
$\leqslant$23 lb	1.2	0.7–2.1
$>$23 lb	1.7	0.9–3.1
Pulling:		
Never	1	Referent
$\leqslant$56 lb	1.2	0.7–2.2
$>$56 lb	1.5	0.8–2.5
Kneeling:		
Never	1	Referent
$<$15 min	1.3	0.8–2.0
$\geqslant$15 min	1.6	0.99–2.7
Psychosocial factors		
Job demand		
Monotonous work:		
Never/occasionally	1	Referent
At least half of the time	1.8	1.1–2.8
Working conditions		
Work in hot conditions:		
No	1	Referent
Yes	1.7	1.1–2.6
Other pain		
No	1	Referent
Yes	1.5	1.1–2.1

[a]Adjusted for gender, age group, occupation and all other factors in the model

Participants vs *non-participants*

Follow-up participation rates varied according to occupational group. At 12 months, response rates ranged from 44% in army infantry to 89% in retail workers. Overall, at 24 months, response rates tended to be higher. The lowest response rates were in the army infantry and postal workers (65%).

More women than men responded at 12 months and the same was true at 24 months, although the difference did not reach statistical significance. There were no statistically significant differences in terms of age between responders and non-responders at 12 and 24 months, although at 12 months, responders tended to be slightly older than non-responders.

Due to the prospective nature of this study, we were able to determine whether there were any differences in the relationship between baseline exposures and outcome in those who did and did not respond at 24 months. For those factors included in the final multivariate model there were no statistically significant differences in the baseline predictors of developing new-onset LBP at 12 months in those who did and did not participate at 24 months.

Discussion

Individual and work-related mechanical and psychosocial exposures have been widely implicated in the onset of LBP. However, the precise nature of these relationships has been unclear. In the present study, conducted amongst young newly employed workers, we have demonstrated that mechanical factors, including lifting and pulling heavy weights were important predictors of new LBP. Psychosocial and physical environment factors were also important in symptom onset with monotonous work and hot working conditions strongly associated with future LBP. However, when assessing the relative contribution of these factors it was the latter work-related psychosocial and environmental factors that significantly predicted new symptom onset.

In interpreting these findings there are several methodological features of the study that need to be considered. First, work exposures were assessed during the last working day and these may not reflect a ‘typical’ working day. To gauge how characteristic the study day was, individuals were asked whether they felt that the past working day was as physically demanding as usual. The majority reported at both time points that it was about the same as usual: 56% at baseline and 66% at

12 months. Importantly, these proportions did not differ between those reporting or not-reporting new LBP.

Second, subjects were assessed at three time points (baseline, 12 and 24 months) and we made no attempt to ascertain any changes in exposure or outcome status during the intervening months. Therefore we are unable to say anything about the new-onset prevalence rate during that time; nevertheless this does not affect the internal comparisons between predictors and outcomes in our study. In the final multivariate model we also assessed interaction terms for exposures by follow-up period to determine whether the relationship between exposure and outcome had changed from baseline to follow-up at 12 months. None of the interaction terms by follow-up period met our inclusion criteria, demonstrating that there was relative stability in the relationship between exposure and outcome over time.

Third, studies of occupational cohorts are typically subject to the healthy worker effect, whereby individuals who develop the outcome of interest may leave the workforce or may change certain aspects of their job. In order to minimize the healthy worker effect we conducted this study within new employees. However, even in this group, of those who responded at 12 months and 24 months, 46 (8%) and 21 (5%) individuals reported having changed their job, respectively. No one reported changing their job because of aches and pains. It is likely that, owing to the nature of the jobs, the study cohort was initially healthier than the general population. As a result we may have underestimated the prevalence of new-onset LBP, but this would not affect the internal comparisons between exposure and outcome.

To minimize recall bias we asked individuals about any aches and pains they had experienced in the lower back in the past 24 h and therefore we may have identified episodes that were transient in nature. However, a fairly large proportion reported that this pain had prevented them from carrying out their usual activities either at home or in the work place (approximately 35%), which would tend to suggest the contrary.

The prevalence rate of new-onset LBP amongst this cohort of young and newly employed workers was high. Many employees were young and undergoing training or starting a new job, therefore exposure to risk factors may have been different to those in workers from well-established jobs. Indeed, the number of subjects exposed to adverse work-related psychosocial factors was low. Nevertheless, despite being at an early stage of employment, work-related mechanical factors, psychosocial and environmental factors were found to predict new-onset LBP.

The results on regional musculoskeletal pain from the cross-sectional phase of this study have been published previously [10, 19]. The current study examines the relative contribution of these factors as predictors of new-onset LBP by taking advantage of the prospective study design. Like the current study many of the manual handling activities involving heavy weights, including lifting with one or two hands, were found to be associated with LBP [19]. Of the work-related psychosocial factors, stress was strongly associated with LBP, whereas in the current study monotonous work was identified as an important predictor of new-onset LBP. Higher levels of individual psychological distress on the GHQ were associated also with LBP in the cross-sectional phase of the study [10]. The cross-sectional phase of the study was not able to disentangle the relationship between exposure and outcome, for example whether individuals reported high levels of psychological distress prior to LBP onset or as a result of LBP. Whereas, the prospective design allows us to conclude that monotonous work was a significant predictor of symptom onset.

One recent study, which examined the effects of work-related psychosocial [20] and mechanical [21] factors in the onset of new LBP in individuals from 34 companies, reported that none of the factors measured significantly predicted symptom onset. Subjects in that study were from a well-established workforce and the results may have been influenced by the healthy worker effect. In a further analysis, amongst subjects who had been employed in their current job for under 5 yr, certain aspects of trunk flexion and rotation, as well as lifting 25 kg more than 15 times per working day, were found to be associated with symptom onset [21].

There have been two other recent studies that have been conducted amongst new workers [22, 23]. The first study was conducted amongst workers of a manufacturing plant [22]. High workload was found to predict low back disorders in men, but the association was not statistically significant. However, this study examined the incidence rate of first sick leave as a result of low back disorders, which is likely to have different risk factors to those for LBP onset. In the second study, conducted amongst student nurses, a history of LBP and high levels of distress, as measured by the GHQ, were found to predict LBP at the time of the follow-up survey [23]. However, a large proportion of students dropped out during the 3-yr training period, with only 32% providing complete data throughout the entire study period. Furthermore, that study did not distinguish between new-onset and persistent episodes of LBP.

Physical working environmental conditions have not been investigated frequently in the literature with respect to LBP. In the present study we found that reports of working in hot conditions significantly predicted new symptom onset. A review of the literature of work-related studies conducted within the People's Republic of China reported that exposure to low temperatures was associated with an increased risk of LBP (prevalence ratios 2.6–9.4) [24]. Similar findings were also reported by Pienimaki [25] in a review of cold exposures and musculoskeletal disorders. We are unsure as to the explanation for our finding. On further analysis we found that shipbuilders who worked in hot conditions had an increased risk of new-onset LBP. This group is likely to be exposed to hot working conditions in certain activities such as welding and furnace work, which may be confounded by other unmeasured factors, for example working postures.

A growing body of evidence points to an increased risk of future back pain for a number of work-place psychosocial variables including job satisfaction, monotonous work, relationships with supervisors and colleagues, job demands and stress [7]. Our study cohort comprised individuals who were newly employed and reports of monotonous or boring work were relatively uncommon. Nevertheless, we found monotonous work to be one of the strongest predictors of new-onset LBP at follow-up. The results of the current study are consistent with our previous reports showing monotonous work to be related to an increased risk of developing forearm pain [E. S. Nahit *et al.*, unpublished work], shoulder pain [E. F. Harkness *et al.*, unpublished work] and disabling shoulder pain [15]. Other studies have also found monotonous work to predict sick leave absences in individuals with acute LBP [26, 27].

What therefore are the implications of these findings? Work-place intervention studies have focused mainly on the physical environment [28] such as reducing harmful mechanical exposures. Implementing and demonstrating the effectiveness of such interventions is often difficult and many studies have produced mixed results [28–31]. The present findings highlight the psychosocial work environment as one possible area of intervention. Symonds *et al.* [32] found that a psychosocial intervention in the form of an educational pamphlet on fear avoidance behaviour reduced extended absences owing to LBP.

In summary, we have demonstrated that work-related mechanical and psychosocial factors, as well as working conditions, were important factors in the development of new-onset LBP. This study highlights the importance of introducing interventions aimed at newly employed workers targeting both the physical and psychosocial work environment.

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Conflict of interest

The authors have declared no conflicts of interest.

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Appendix: Sources of recruitment

(1) Newly opened work places in the North West of England that required a new workforce. First, a recently opened supermarket comprised employees from a number of areas including checkouts, shelf stacking, service counters, a crèche, general office and stock management staff. Second, workers from a postal distribution centre responsible for unloading and loading trolleys of mailbags on and off trains and lorries; other workers were employed in administration or catering.

(2) Service organizations that frequently recruit groups of trainees. A total of nine intakes of full-time paid fire-fighters, from four local counties, in their period of initial training. All police force trainees from three intakes of one police force were invited to participate. New army recruits including officers, infantry and clerks. Officers from three companies were selected at random, as were infantry soldiers from two battalions and all clerks enrolled on three training intakes were included.

(3) Apprentices, carrying out construction and engineering tasks, from an established shipbuilding company were invited to participate.

(4) Individuals at the end of vocational courses who were training for specific careers were also recruited. This group included nursing students from one academic institution, dentistry students from two academic institutions, all podiatry students from a further two academic institutions and forestry students at a specialised college.