Occup Environ Med 2000;**57**:28–34

Cohort study of occupational risk factors of low back pain in construction workers

Ute Latza, Wilfried Karmaus, Til Stürmer, Markus Steiner, Axel Neth, Uwe Rehder

Abstract

***Objectives*—To identify work related risk factors of future low back pain (LBP) in a cohort of construction workers free of LBP at the start of follow up.**

***Methods*—The Hamburg construction worker study comprises 571 male construction workers who have undergone two comprehensive interview and physical examination surveys. A cohort of 285 subjects without LBP at baseline was identified. After a follow up of 3 years, the 1 year prevalence of self reported LBP was determined in the 230 men followed up (80.7%). Prevalence ratios (PRs) with 95% confidence intervals (95% CIs) of LBP at follow up according to self reported work tasks of construction workers measured at baseline were estimated from Cox's regression models which were adjusted for age, and anthropometric measures.**

***Results*—At follow up 71 out of 230 workers (30.9%) reported LBP during the preceding 12 months. Four work tasks (scaffolding, erecting roof structures, sawing wood, laying large sandstones) with an increased risk of 1 year prevalence of LBP at follow up were further evaluated. After further adjustment for occupation the relative risk was increased for workers who had reported ⩾2 hour/shifts laying large sandstones (PR=2.6; 95% CI 1.1 to 6.5). Work load of bricklayers was additionally estimated by an index on stone load (high exposure: PR=4.0; 95% CI 0.8 to 19.8), and an index for laying huge bricks/blocks (yes/no: PR=1.7; 95% CI 0.5 to 5.7).**

***Conclusions*—The results suggest that self reported differences in brick characteristics (size and type of stone) and temporal aspects of the work of bricklayers (average hours per shift laying specified stones) can predict the future prevalence of LBP. The data have to be interpreted with caution because multiple risk factors were tested.**
(*Occup Environ Med* 2000;**57**:28–34)

Keywords: construction industry; cohort studies; low back pain

NORDIG Institute for Health Research and Prevention, Hamburg, Germany
U Latza
W Karmaus
M Steiner
A Neth

Department of Epidemiology, University of Ulm, Ulm, Germany
T Stürmer

Department of Orthopaedic Surgery, University Hospital Eppendorf, Hamburg, Germany
U Rehder

Correspondence to:
Dr U Latza,
Berufsgenossenschaftliches Forschungsinstitut fuer Arbeitsmedizin (BGFA),
D-44789 Bochum,
Buerkle-de-la-Camp-Platz 1,
Germany
email latza@bgfa.ruhr-uni-bochum.de

Accepted 15 September 1999

Symptoms associated with back disorders, in particular low back pain (LBP), account for a large percentage of all sickness absence in western industrialised countries.[1 2] In Germany, about 14% of the days lost from work are due to back disorders.[1] Some trades are characterised by a comparatively high prevalence of musculoskeletal disorders with the construction industry ranking third for sickness absence due to LBP in Germany.[1 3] Several cross sectional studies have suggested that bricklayers bear a particularly high risk of developing LBP[4] and low back disorders.[5 6] However, job title is only a crude measure of the occupational exposure. More information on specific work tasks is needed to recognise factors which increase the future risk of LBP.

Low back pain is a complex condition with several factors contributing to its occurrence. Most knowledge on risk factors of LBP stems from cross sectional studies which cannot evaluate the temporal sequence between a risk factor and the occurrence of pain.[7] Three different groups of potential risk factors have been identified[2 7]: (*a*) individual factors such as body weight and age, (*b*) biomechanical factors such as heavy physical load, lifting, twisted postures, and vibration, and (*c*) psychosocial factors such as job control and job satisfaction. The increased risk for bricklayers has been attributed to inclined work postures and by repetitive lifting of bricks which weigh 5–24 kg, depending on the type and size.[5]

In this longitudinal study we wanted to identify potential risk factors of LBP among construction workers, with a focus on bricklayers. For this purpose, the associations between self reported specific work tasks at baseline and occurrence of LBP at follow up were evaluated among a cohort of construction workers without LBP at baseline. Additionally, work characteristics of the stones and bricks used by bricklayers were further analysed to identify potentially modifiable risk factors.

Subjects and methods

STUDY SUBJECTS

The Hamburg construction worker study is a longitudinal epidemiological study initiated to identify risk factors of musculoskeletal disorders in the construction industry. The baseline survey in 1992-3, which has been described in detail[6] involved 571 male construction workers aged 17–59 who lived in the area of Hamburg, Germany. Of these, 371 were recruited from a routine health check up (employer's liability insurance), 108 were sent by their employers, 60 were recruited directly through advertisements, and 32 were recruited from vocational schools. After about 3 years from May 1995 until July 1996 all workers were approached either directly or through their employers for a follow up survey; 488 could be traced and were willing to participate (follow up 85.5%). The interview and examination survey in 1995–6 was almost identical to the follow up survey in

1992–3. No changes were made to questions which were evaluated in this analysis. The study was approved by the local ethics committee.

A cohort of subjects without LBP at baseline was identified. Out of the 285 workers without LBP at baseline 55 men were lost to follow up (19.3%). The cohort of this analysis included those 230 workers without LBP at baseline who were followed up. Every participant was grouped into a job category according to the job held at baseline.

Multiple logistic regression was used to identify factors associated with losses to follow up.[8] At baseline LBP was associated with a decreased risk of non-participation in the follow up survey whereas cumulative years of unemployment were associated with an increased risk.

DATA COLLECTION

After written informed consent the workers participated in a structured interview and examination survey. The interview covered a complete job history including broad job tasks and work organisation, as well as information on demography, education, psychosocial factors, lifestyle factors, health status, and pain in different body regions. During the interview, all participants were specifically asked about the occurrence of LBP during the preceding 12 months. The low back was defined as the region of the lumbar spine and was specified by a figure, in case of ambiguity. If workers affirmed the question on LBP, further information concerning the temporal pattern and type of pain was gathered. For this analysis information on age, work tasks (average hours per shift during the preceding 12 months), occupation, and LBP at baseline was used. The detailed standardised orthopaedic examination has already been described.[6 9] In this analysis anthropometric measures at baseline (sitting height, height, weight) were considered as initial confounders. For the follow up survey in 1995–6, participants were again interviewed and examined.

A reliability study at follow up was conducted among a subpopulation of this study.[10] For the reliability study, a sample of 43 workers which was over sampled for subjects with clinical signs of low back disorders at baseline or at follow up were interviewed twice within about 6 weeks. Reproducibility of self reported information on work tasks was assessed by the within class correlation coefficient[11] and interpreted according to Altman.[12]

ANALYSIS OF DATA

Work tasks of construction workers as potential risk factors of future LBP were identified with an exploratory approach. One physical aspect of the work of bricklayers was investigated with questions about details of the bricks or stones. Based on initial assumptions two indices on stone size and load were constructed and tested.

The associations between LBP and work tasks including specific details of the stones or bricks were analysed with a three step hierarchical approach. Firstly, reproducibility of information on 37 work tasks including six specific stone or brick types was assessed in 43 people with repeated measures.[10] The strength of agreement of six tasks (cleaning, maintenance of equipment, reconstruction, cladding or shuttering, steel fixing, smoothing surfaces) and laying one type of stone (2–3DF concrete blocks) was less than moderate (within class correlation coefficient ⩽0.40). One task specific to house painters (attaching panels) and laying two types of brick or stone (>3DF concrete blocks, >3DF sandstone) could not be evaluated due to lack of variability of the reported working hours.

Secondly, if the within class correlation coefficient was >0.40, the association between LBP at follow up and baseline information on performed work tasks was analysed by multivariate modelling. For this purpose the remaining 27 work tasks were categorised into five groups: (*a*) eight general tasks of construction workers, (*b*) five tasks specific to carpenters or concrete builders, (*c*) four tasks specific to house painters, (*d*) seven tasks specific to bricklayers, and (*e*) laying three different types of bricks or stones. Average daily hours of work tasks during the preceding 12 months were scaled dividing the number of hours by eight. The dependent variable was the 1 year prevalence of LBP (yes or no) at follow up among subjects free of LBP at baseline. Cox's regression models were fitted to the data, which were adjusted for age (⩽25, >25–30, >30–35, >35–40, >40–45, >45–50, >50 years), sitting height (cm), and body mass index (kg/m^2)

Table 1 Characteristics at baseline of all subjects of the Hamburg construction worker study without low back pain at baseline (n=285) who were followed up or lost to follow up

	With follow up (n=230)				*Lost to follow up (n=55)*			
Variables	*Mean*	*SD*	*Median*	*Range*	*Mean*	*SD*	*Median*	*Range*
Individual factors:								
Age (y)	32.51	9.16	31	17–57	27.69	9.08	26	17–51
Body mass index (kg/m^2)*	25.91	4.42	25	18–41	25.69	4.61	25	18–37
Sitting height (cm)†	94.72	3.53	95	85–107	94.34	2.74	94	88–103
Psychosocial work factors‡:								
Monotonous work	2.16	1.28	2	1–5	2.87	1.48	3	1–5
Time pressure	2.90	1.32	3	1–5	2.47	1.18	2	1–5
Low job control	2.38	1.10	2	1–5	2.56	1.30	2	1–5
Poor social support	1.45	0.78	1	1–5	1.60	0.94	1	1–5
Job satisfaction	3.57	1.21	4	1–5	3.49	1.44	4	1–5

*Subjects with missing values excluded: n=3/230 with follow up, and n=1/55 lost to follow up.
†Subjects with missing values excluded: n=3/230 with follow up, and n=2/55 lost to follow up.
‡Measured by a five point Likert scale ranging from 1=definitely false, to 5=definitely true.

Table 2 Selected back pain characteristics at follow up among members of the cohort without low back pain at baseline and for comparison all subjects of the Hamburg construction worker study at baseline

	All subjects (n=571)		Cohort (n=230)	
Back pain characteristic	n	%	n	%
Low back pain	286	50.1	71	30.9
Low back pain during or after unusual movements or tasks	195	34.2	52	22.6
Permanent low back pain	164	28.7	28	12.2
Sudden attack of low back pain (lumbago)	119	20.8	34	14.8
Low back pain radiating to the leg (sciatic pain)	104	18.2	24	10.4

Table 3 Exposure to work tasks which were evaluated as potential risk factors and association with 1 year prevalence of low back pain at follow up among the cohort without low back pain at baseline (n=230)

Group of work tasks; specific task	Exposure mean h/8h shift ÷ 8 (SD)	Association with low back pain PR (95% CI)*
General tasks†:		
Pointing up	0.044 (0.137)	0.1 (0.0 to 3.3)
Supportive tasks	0.084 (0.159)	0.3 (0.0 to 2.7)
Supervision	0.098 (0.198)	0.3 (0.1 to 1.6)
Impregnation	0.044 (0.108)	0.8 (0.1 to 8.5)
Driving trucks	0.056 (0.149)	0.8 (0.2 to 3.7)
Transport of material	0.131 (0.15)	1.2 (0.2 to 5.7)
Loading of material	0.062 (0.070)	1.7 (0.1 to 52.7)
Scaffolding	0.034 (0.058)	15.4 (0.5 to 471.0)
Tasks specific to carpenters/concrete builders‡:		
Setting up form work	0.085 (0.219)	0.9 (0.3 to 3.1)
Concrete distribution	0.311 (0.082)	1.8 (0.1 to 30.2)
1st, 2nd, and 3rd fixings	0.087 (0.199)	2.3 (0.9 to 6.2)
Sawing wood	0.025 (0.079)	5.2 (0.4 to 74.0)
Erecting roof structures	0.029 (0.090)	6.0 (0.8 to 44.7)
Tasks specific to house painters§:		
Stripping colour or wall paper	0.055 (0.137)	0.2 (0.0 to 2.3)
Hanging wall paper	0.091 (0.201)	0.3 (0.0 to 1.1)
Painting by rolling	0.099 (0.195)	0.7 (0.0 to 2.7)
Painting by brushing	0.085 (0.175)	0.8 (0.2 to 3.4)
Tasks specific to bricklayers¶:		
Repairing walls	0.017 (0.077)	0.4 (0.0 to 20.0)
Laying face bricks	0.014 (0.078)	1.0 (0.1 to 19.4)
Building walls	0.103 (0.214)	1.6 (0.5 to 4.6)
Laying lintels or sills	0.065 (0.141)	1.7 (0.3 to 8.7)
Mixing mortar	0.033 (0.085)	2.1 (0.2 to 25.9)
Plastering	0.012 (0.072)	2.1 (0.1 to 40.6)
Demolition	0.008 (0.056)	3.6 (0.3 to 52.0)
Laying specific brick formats**:		
Clinker (0.8 to 1.4 kg)	0.068 (0.161)	0.9 (0.2 to 4.7)
2DF sandstone (4 to 6.5 kg)	0.085 (0.176)	2.4 (0.7 to 8.1)
3DF sandstone (7 to 10 kg)	0.064 (0.145)	3.5 (0.9 to 12.8)

*PR (95% CI) for a duration of 8 hours during an average 8 hour shift adjusted for age (≤25/>25–30/>30–35/>35–40/>40–45/>45–50/>50 years), sitting height (cm), and body mass index (kg/m^2).
†Pearson correlation coefficient 0.48 (supervision and supportive tasks), 0.39 (transport of material and loading of material).
‡Pearson correlation coefficient 0.77 (sawing wood and erecting roof structures), 0.47 (1st, 2nd, and 3rd fixings and erecting roof structures), 0.40 (1st, 2nd, and 3rd fixings and sawing wood.)
§Pearson correlation coefficients: 0.79 (hanging wall paper and painting by brushing), 0.79 (painting by rolling and painting by brushing), 0.72 (hanging wall paper and painting by rolling), 0.66 (hanging wall paper and stripping colour or wall paper), 0.66 (painting by rolling and stripping colour or wall paper, 0.58 (painting by brushing and stripping colour or wall paper).
¶Pearson correlation coefficient 0.68 (building walls and laying lintels or sills).
**Pearson correlation coefficient 0.88 (2DF sandstone and 3DF sandstone), 0.48 (2DF sandstone and clinker), 0.39 (clinker and 3DF sandstone).

as initial confounders with the PHREG procedure of SAS assuming a constant risk period.[13] Prevalence ratios (PRs) with 95% confidence intervals (95% CIs) were calculated. Potential collinearity within a group of work tasks was assessed by the Pearson correlation coefficient. Correlation coefficients >0.3 are reported.

As the third step, the work tasks which were associated with a high risk of 1 year prevalence of LBP at follow up (PR>3) were selected for further analysis. Also, two stone indices were tested; an index for measuring stone load (sum of mean stone mass for each type of brick or stone multiplied by hours a day working with that stone type), and an index for laying oversized (>3DF) concrete blocks or sandstones which normally weigh at least 10 kg and require both hands for gripping (yes or no). The work tasks and the index on stone load were grouped into three categories according to the tertiles of their distributions in the 230 workers without LBP at baseline. The PRs are presented as crude estimates, adjusted for initial confounders, and additionally adjusted for self reported occupation at baseline (five categories). Psychosocial factors at work which have been related to back pain and back disorders[14] (monotonous work, time pressure, low job control, poor social support, job satisfaction) were considered as potential confounders. The psychosocial factors at work which were measured by a five point Likert scale ranging from strongly disagree (1) to strongly agree (5) were recoded into three categories based on the distribution of the cohort at baseline. Confounding was reported if a change of >15% in the adjusted risk estimates occurred after additionally adjusting for the covariates in separate models. A test for trend (Wald test) was conducted adding the exposure variables with three levels of exposure to the adjusted models as grouped linear variables. Subjects with missing values were excluded as indicated in the tables presented. A two sided α level of 0.05 was considered significant.

Results

Selected subject characteristics at baseline are presented in table 1. The baseline characteristics of the cohort without LBP at baseline who were followed up (n=230) were similar to the characteristics of the subjects without LBP at baseline who were lost to follow up (n=55) except for age and two psychosocial work factors. Subjects who were lost to follow up were about 5 years younger than the subjects who were followed up. They were more likely to report monotonous work and less likely to report time pressure at baseline.

Information on the job category at follow up was used to determine a change of occupation between baseline and follow up. Among the respondents without LBP at baseline a change in occupation was reported by three out of the 55 house painters, 18 out of the 93 bricklayers, seven out of the 41 carpenters, eight of the 26 concrete builders, and six of the 15 unskilled workers.

After a mean follow up of 2.88 years (SD 0.22, median 2.87, range 2.47–4.00) 30.9% of the cohort reported LBP within the preceding 12 months. Selected characteristics of back pain are shown in table 2 for the cohort at follow up and for comparison all subjects of the Hamburg construction worker study at baseline (n=571). Low back pain at follow up included lumbago (14.8%) and sciatic pain (10.4%); permanent LBP was comparatively rare (12.2%).

The work tasks which were evaluated as potential risk factors of a 1 year prevalence of LBP at follow up are presented in table 3. Thirteen work tasks were associated with a decreased risk of LBP (five general tasks, one task of carpenters and concrete builders, all tasks of house painters, two tasks of bricklayers, laying one type of stone). Fourteen work tasks were associated with an increased risk of LBP at follow up: three out of eight general work tasks tested (transport of material, loading of material, scaffolding), four out of five tasks specific to carpenters and concrete builders tested (concrete distribution, 1st, 2nd, and 3rd fixings, sawing wood, erecting roof structures), five out of seven tasks specific to bricklayers tested (building walls, laying lintels or sills, mixing mortar, plastering, demolition), and laying two out of three specific types of brick or stone tested (2DF sandstone, 3DF sandstone). Erecting roof structures was highly correlated with sawing wood (Pearson correlation coefficient 0.77); laying 3DF sandstone was highly correlated with laying 2DF sandstone (Pearson correlation coefficient 0.88). The risk estimates for a work load of 8 hours a shift were >3 for scaffolding, sawing wood, erecting roof structures, demolition, and laying 3DF sandstone.

The four work tasks including one stone format which exhibited the strongest associations with the 1 year prevalence of LBP at follow up were further evaluated. Demolition was not further evaluated because only six workers had indicated exposure to this work task. For easier interpretation of the risk estimates, the selected work tasks were categorised into three levels of exposure. The crude and adjusted PRs for the associations between prevalence of LBP at follow up and the selected work tasks as well as both indices are shown in table 4. Among the general work tasks, the risk of 1 year prevalence of LBP at follow up was slightly increased for workers who had reported scaffolding for an average duration of 0.5–3.0 hours/shift (adjusted PR 1.4, 95% CI 0.8 to 2.6). Scaffolding was named by 104 workers, most of whom were bricklayers. Among the tasks of carpenters and concrete builders prevalence of LBP at follow up was increased in workers who had reported erecting roof structures for an average duration of >0.7–4.0 hours/shift (adjusted PR 1.6; 95% CI 0.7 to 3.3) and more than twofold increased in workers who had reported sawing wood for an average duration of >0–1.0 hours/shift (adjusted PR 2.4; 95% CI 1.1 to 5.2). Erecting roof structures was named by 41, and sawing wood by 31 construction workers, respectively; most of whom were carpenters. Laying 3DF sandstones for an average of 2.0–8.5 hours/shift was associated with an increased risk (adjusted PR 1.7; 95% CI 0.9 to 3.1). Most of the 60 workers who named this stone format were bricklayers. Both stone indices were associated with an increased risk of LBP. Subjects who were exposed to high levels of stone load (adjusted PR 1.6; 95% CI 0.9 to 2.9) and subjects who had worked with >3DF bricks or blocks (adjusted PR 1.6; 95% CI 0.5 to 5.1) were more likely to report prevalent LBP at follow up.

None of the psychosocial work factors which were evaluated as potential confounders was a significant risk factor of a 1 year prevalence of LBP at follow up. Psychosocial work factors did not confound the associations between LBP and the potential risk factors evaluated.

The risk of prevalence of LBP at follow up was increased for carpenters (PR 2.5, 95% CI 0.7 to 8.6) and bricklayers (PR 1.5, 95% CI 0.5 to 5.1) compared with unskilled workers. If the models were additionally adjusted for occupation at baseline (table 4) the strength of the associations between prevalence of LBP at fol-

Table 4 Crude and adjusted PR (95% CI) for the association between 1 year prevalence of low back pain at follow up and work tasks or indices among 230 workers without low back pain at baseline

	1 y Prevalence		*Crude and adjusted PR (95% CI)*		
Potential risk factor; specific task or index	*n*	*%*	*Crude estimate*	*Initial confounder**	*Initial confounder and job†*
General tasks (h/shift):					
Scaffolding:					
0	36/126	28.6	1 (reference)	1 (reference)	1 (reference)
>0–<0.5	11/43	25.6	0.9 (0.5 to 1.8)	0.9 (0.4 to 1.8)	0.9 (0.4 to 2.0)
0.5–3.0	24/61	39.3	1.4 (0.8 to 2.3)	1.4 (0.8 to 2.4)	1.4 (0.8 to 2.6)
Tasks of carpenters (h/shift):					
Sawing wood:					
0	54/189	28.6	1 (reference)	1 (reference)	1 (reference)
>0–1.0	8/14	57.1	2.0 (1.0 to 4.3)	2.4 (1.1 to 5.2)	1.7 (0.6 to 4.8)
>1.0–4.0	7/17	41.2	1.5 (0.8 to 3.2)	1.5 (0.7 to 3.5)	1.0 (0.3 to 3.0)
Erecting roof structures:					
0	54/189	28.6	1 (reference)	1 (reference)	1 (reference)
>0–0.7	8/21	38.1	1.3 (0.6 to 2.8)	1.6 (0.7 to 3.5)	1.1 (0.4 to 2.9)
>0.7–4.0	9/20	45.0	1.6 (0.8 to 3.2)	1.6 (0.8 to 3.3)	0.9 (0.3 to 2.6)
Laying defined brick/stone formats (h/shift):					
3DF sandstone‡:					
0	49/170	28.8	1 (reference)	1 (reference)	1 (reference)
>0–<2.0	9/29	31.0	1.1 (0.5 to 2.2)	1.2 (0.6 to 2.5)	1.8 (0.7 to 4.7)
2.0–8.5	13/31	41.9	1.5 (0.8 to 2.7)	1.7 (0.9 to 3.1)	2.6 (1.1 to 6.5)
Stone indices:					
Stone load§:					
None	42/140	28.7	1 (reference)	1 (reference)	1 (reference)
Intermediate	8/38	24.3	0.7 (0.3 to 1.5)	0.8 (0.4 to 1.7)	1.8 (0.3 to 9.3)
High	16/28	50.0	1.4 (0.8 to 2.5)	1.6 (0.9 to 2.9)	4.0 (0.8 to 19.8)
Laying >3DF stones:					
No	58/201	28.7	1 (reference)	1 (reference)	1 (reference)
Yes	13/29	44.8	1.7 (0.5 to 5.2)	1.6 (0.5 to 5.1)	1.7 (0.5 to 5.7)

*Adjusted for age (≤25/>25–30/>30–35/>35–40/>40–45/>45–50/>50), sitting height (cm), and body mass index (kg/m^2); n=227 because of missing values for sitting height and body mass index.
†Adjusted for five categories of occupation at baseline.
‡Subjects with missing values excluded (n=7/230).
§Subjects with missing values excluded (n=4/230).

low up and erecting roof structures or sawing wood, respectively decreased. After adjusting for occupation the risks associated with laying 3DF sandstone (>0–<2hours/shift, PR 1.8, 95% CI 0.7 to 4.7; ⩾2 hours/shift, PR 2.6; 95% CI 1.1 to 6.5; test for trend p=0.03) and stone load (intermediate level, PR 1.8, 95% CI 0.4 to 9.5; high level, PR 4.0, 95% CI 0.8 to 19.8; test for trend, p=0.03), respectively increased with increasing levels of exposure.

Discussion

In this cohort study we investigated specific work tasks of construction workers who were free of LBP at baseline for future occurrence of LBP. The 1 year prevalence of LBP at follow up among exposed workers was compared with other non-exposed construction workers. Comparisons within a rather homogeneous group with a similar socioeconomic background and similar working conditions increases the possibility of identifying particularly hazardous work tasks within the construction industry.

DISEASE FREQUENCY

The 1 year prevalence of LBP, which was about 50% in both surveys of the Hamburg construction worker study, was within the range estimated from population based studies on LBP for the 30–50 year old Nordic population (44%–65%),[15] and for German construction workers aged 40–64 years (48%–60%).[3] The evaluation of the 1 year prevalence (30.9%) of LBP after 3 years of follow up among men free from LBP at baseline in this study renders comparisons with other investigations a difficult task. In the Manchester back pain study the 1 year cumulative incidence of LBP was 31% after 1 year follow up among men initially free of LBP.[16]

ASSOCIATION BETWEEN PREVALENCE OF LBP AT FOLLOW UP AND WORK TASKS

Self reported work tasks of construction workers were identified as potential risk factors of LBP based on the reproducibility of the exposure assessment and the strength of the associations with LBP. For construction workers with constantly changing building sites which are characterised by different working conditions, such as auxiliary technical devices, self reported integrated exposure over a period of 12 months may provide relevant information to guide the focus of preventive actions. One general task of construction workers (scaffolding) and two work tasks of carpenters and concrete builders (sawing wood and erecting roof structures) were associated with particularly high risks of prevalence of LBP at follow up. The associations between LBP at follow up and work tasks specific to bricklayers were either comparatively weak or not enough workers reported exposure to the tasks which were investigated.

Both work tasks and occupation can be regarded as crude measures of biomechanical risk factors of LBP; they can be highly correlated. However, overlapping of work tasks between different occupational titles can occur. Controlling for occupation may explain whether the selected work tasks of carpenters and concrete builders contributed additionally to the already described increased risk of LBP for carpenters.[4 5] In this study, the risk of LBP of carpenters at follow up was increased compared with unskilled construction workers. After additionally adjusting for job category the relative risks associated with sawing wood and in particular with erecting roof structures decreased. Thus, only some additional aspects in the work of a carpenter which increased the risk of future LBP were assessed with these work tasks.

The reported increased risks associated with work tasks of carpenters support the earlier mostly cross sectional studies which have mainly focused on job titles. Compared with other construction workers increased risks were reported for carpenters.[4 5] In a Swedish random sample of construction workers with different occupations LBP was significantly associated with a material handling index for carpentry.[17] In a Finnish cohort study the risk of incident sciatic pain was increased for construction carpenters compared with office workers.[18]

The direct measurements at the workplace which were undertaken within the ergonomic part of the multidisciplinary Hamburg Bauarbeiter study[19 20] might help to explain the observed risks associated with specific work tasks of carpenters and the wide 95% CIs for the risk estimates. Some of the workers who participated in the baseline survey of the present study were probably participants of the ergonomic measurements among 95 construction workers (bricklayers, house painters, carpenters, and concrete builders). Due to confidentiality regulations in Germany the data from the direct measurements could not be linked to the data from the survey. Although Grünwald emphasised that lifting and carrying heavy loads weighing >50 kg was a particularly hazardous task when erecting roof structures she noted that the work tasks sawing wood and erecting roof structures differed markedly depending on the specific roof construction and on the technical devices in use.[20] Grünwald did not analyse the work load when erecting scaffoldings. One might speculate that the slightly increased risk associated with scaffolding in this study might also be attributable to moving heavy loads. The reported increased risks associated with sawing wood is in agreement with another ergonomic evaluation. With a job analysis based on work sampling Punnett and Paquet found that the heaviest loads of carpenters in tunnel construction were handled in indoor sawing and material moving.[21]

ASSOCIATION BETWEEN PREVALENCE OF LBP AT FOLLOW UP AND TYPES OF BRICKS OR STONES

With the questions on specific types of bricks or stones we evaluated whether potentially hazardous aspects of the work load of bricklayers that lead to LBP could be identified by the type and size of the stones and bricks handled. Also, the association between LBP at follow up and two stone indices which were constructed based on initial assumptions[5] were tested. Both of the comparatively heavy sandstones which were evaluated were associated with an increased risk of future LBP. Laying 2D sandstones and 3DF sandstones were highly correlated, and the risk of LBP associated with laying 3DF sandstone was higher. Based on the strength of the association with LBP laying 3DF sandstone was further analysed. Both stone indices were associated with increased risks. The effects were most pronounced when the models were additionally adjusted for occupation. If occupation was included into the models, the risk of LBP associated with the larger (3DF) sandstones, which weigh about 7–10 kg, was increased more than twofold for a work load of at least 2 hours a shift. The risk was increased nearly twofold for laying huge and heavy (>3DF) stones which require both hands for gripping and was increased fourfold for workers who were exposed to high levels of the index on stone load which measured both the duration and the weight of stones moved during an average shift. After adjusting for occupation, laying large sandstones and stone load showed a dose-response relation; the risks increased with increasing levels of exposure. Both occupation and the analysed work tasks are surrogate measures of the biomechanical risk factors of LBP. Classification of the exposure based on work tasks may be more precise than the classification based on job titles because not all bricklayers were exposed to laying stones or bricks. The results may be interpreted that being a bricklayer alone bears a lower risk than being a bricklayer who lays 3DF or larger stones.

The reported increased risk of LBP associated with physical aspects of the work of bricklayers may explain the increased risk of bricklayers previously found in cross sectional studies[4 5] and in the analysis of the baseline survey of the Hamburg construction worker study.[6] In the ergonomic evaluation Grünwald characterised the handling of sandstone as a comparatively strenuous task.[20] Manipulating 3DF sandstones comprised up to 210 kg/hours of the load moved by bricklayers.[20] To our knowledge hazardous aspects of the work of construction workers have not yet been evaluated for their effect on the future occurrence of LBP. There is a need to evaluate different assessment strategies of physical work load at the workplace within longitudinal studies to guide effective primary interventions.

VALIDITY OF THE RESULTS

Selection into and out of the Hamburg construction worker study has occurred. In a comparison of the age distribution of the non-random sample of the study with a representative occupation based sample of German men aged 18–50 years,[22] no significant difference in age was found for bricklayers and carpenters (data not shown). However, the results may not be representative for German house painters, and concrete builders because house painters and concrete builders aged 30–40 years were preferentially selected into the baseline survey. Analysis of factors that were associated with a selection out of the Hamburg construction worker study showed that the results may not apply to subjects who had been previously unemployed. In this analysis, participants of the Hamburger construction worker study who reported LBP at baseline were not included. Compared with all subjects of the Hamburg construction worker study the members of the cohort were less likely to report permanent LBP at follow up. As a consequence, the data from this analysis on potential risk factors for a prevalence of LBP at follow up may not apply to subjects who have permanent LBP. The workers who were lost to follow up were slightly younger than the subjects with follow up but the percentage of losses to follow up was comparatively small.

Low back pain is an ill defined, recurrent event. It is not clear whether the prevalence of LBP after a 1 year of follow up in this study had started before the 12 month period or whether it refers to the first or a new event after a long disease free interval.[23] No information on LBP during the 2 years after the baseline survey was obtained because this information is particularly prone to misclassification.[24] The reported risks in this study will be underestimated when exposed workers had recovered from LBP during follow up because they had changed to less hazardous work tasks because of LBP. Change in the exposure of the investigated work tasks and in occupation occurred between baseline and follow up. In a subanalysis among subjects who did not report a change in the exposure variables between baseline and follow up, the reported increased risks associated with laying 3DF sandstones and both stone indices remained largely stable (data not shown). In analyses of subcohorts without change of occupation between baseline and follow up, the risk estimates were similar to the reported risks (data not shown).

In this study the outcome and the exposure variables were based on subjective measurements. With the longitudinal study design the authors diminished the possibility that workers overestimated their perception of pain due to strenuous working conditions.[24] With the approach to exclude all subjects with LBP at baseline, misclassification of the exposure due to the perception of LBP[25] can be ruled out. Further, the quality of the exposure measurement was increased because only reproducible information on tasks was used to identify potential risk factors for the prevalence of LBP at follow up.

The risk estimates were adjusted for many potential confounders which may contribute to the complex mechanisms leading to LBP such as anthropometric measures, age, and psychosocial work factors.[7 14] We did not adjust for previous LBP because of potential misclassification.[18] Thus, it seems unlikely that the reported associations between specific work tasks and prevalence of LBP at follow up can be explained by other factors.

Chance may account for the findings because 27 work tasks (including three types of bricks or stones) and two stone indices were tested for significance and the reported 95% CIs of most risk estimates were wide. To adjust for multiple comparisons, a significance level of 0.0017 (Bonferroni method) would be needed. However, a conservative approach was taken with the Cox's models, which give risk estimates which are close to the true variable but produce SEMs which are too wide, especially when the prevalence of the disease is high.[13]

Conclusions

We were able to identify specific work tasks which predicted the future prevalence of LBP. Causality cannot be established with this study. The strength of the associations, the dose effects, the temporal sequence, and the coherence of the findings with an ergonomic evaluation favour a possible causal relation between LBP and laying large sandstones or stone load.[26] The identification of hazardous components in the work of construction workers may contribute to the recognition of an occupational disease and to guide effective primary interventions. The enforced use of technical devices for lifting and moving heavy loads during sawing and when erecting roof structures or scaffolding, as well as reduction in brick mass and brick size seem most amenable to change.

The study was supported by a grant from the German Federal Ministry for Research and Technology (BMBF No HG019/1). We thank the construction workers for their participation and the employer's liability insurance (Bau-Berufsgenossenschaft Hamburg), and the employers for their efforts in the recruitment of participants.

1 *Krankheitsarten 1995.* Essen: BKK Bundesverband, 1997.
2 Frank JW, Kerr MS, Brooker A-S, *et al.* Disability resulting from occupational low back pain. *Spine* 1996;**21**:2909–17.
3 Rothenbacher D, Brenner H, Arndt V, *et al.* Disorders of the back and spine in construction workers: prevalence and prognostic value for disability. *Spine* 1997;**22**:1481–6.
4 Yoshida T, Goto M, Nagira T, *et al.* Studies on low back pain among workers in small scale construction companies. *Japan Journal of Industrial Health* 1971;**13**:37–45.
5 Kopf T, Karmaus W. Risks for musculo-skeletal disorders of the low back, the shoulders, the elbows, and the wrists in bricklayers. In: Hogstedt C, Reuterwall C, eds. *Progress in occupational epidemiology*. Amsterdam: Elsevier, 1988:218–22.
6 Stürmer T, Luessenhoop S, Neth A, *et al.* Construction work and low back disorder: preliminary findings of the Hamburg construction worker study. *Spine* 1997;**22**:2558–63.
7 Riihimäki H. Low-back pain, its origin and risk indicators. *Scand J Work Environ Health* 1991;**17**:81–90.
8 Latza U, Karmaus W, Rehder W. *Wer scheidet aus der Studie aus? Befunde aus der Hamburger Bauarbeiter-Studie (Who is lost to follow up? Results from the Hamburg Construction Worker Study). Proceedings of the 6th National Meeting of the Deutsche Arbeitsgemeinschaft Epidemiologie (DAE)*. Mainz: German Association of Epidemiologie, 1998:33.
9 Soyka M, Toussaint R, Lüssenhop S, *et al. Eppendorfer Orthopädischer Untersuchungsbogen (EOU) (Eppendorf data collection form for orthopaedic examinations)*. Berlin: Bundesanstalt für Arbeitsmedizin, 1995.
10 Latza U, Karmaus W, Steiner M. *The reproducibility of self-reported information on work tasks and pain. Procedures of the 13th International Symposium on Epidemiology on Occupational Health and the 3rd International Scientific Conference on Prevention of Work-Related Musculoskeletal Disorders (PREMUS-ISEOH 1998)*. Helsinki: Finnish Institute of Occupational Health, 1998:52.
11 Armstrong BK, White E, Saracci R. Analysis of validity and reliability studies. In: *Principles of exposure measurement in epidemiology. Monographs on epidemiology and biostatistics.* New York: Oxford University Press, 1992:94–114.
12 Altman DG. Inter-rater agreement. In: *Practical statistics for medical research*. London: Chapman and Hall, 1991:403–9.
13 Skov T, Deddens J, Petersen MR, *et al.* Prevalence proportion ratios: estimation and hypothesis testing. *Int J Epidemiol* 1998;**27**:91–5.
14 Bongers P, de Winter CR, Kompier MAJ, *et al.* Psychosocial factors at work and musculoskeletal disease. *Scand J Work Environ Health* 1993;**19**:297–312.
15 Leboef C, Klougart N, Lauritzen N. How common is low back pain in the Nordic population? *Spine* 1996;**13**:1518–26.
16 Papageorgiou AC, Croft PR, Thomas E, *et al.* Influence of previous back pain experience on the episode of low back pain: results from the south Manchester back pain study. *Pain* 1996;**66**:181–5.
17 Holmström E, Lindell J, Moritz U. Low back and neck/shoulder pain in construction workers; occupational work load and psychosocial factors. Part 1: relation to low back pain. *Spine* 1992;**17**:663–71.
18 Riihimäki H, Viikari-Juntura E, Moneta G, *et al.* Incidence of sciatic pain among men in machine operating, dynamic physical work, and sedentary work: a three year follow up. *Spine* 1994;**19**:138–42.
19 Grünwald C, Becker G, Fleischer AG. Arbeitsbelastung und zeitliche Struktur der Bauarbeit (Work load and temporal structure of skilled manual work). *Zeitschrift für Arbeitswissenschaft* 1998;**4**:250–9.
20 Grünwald C. *Zeitliche Organisations und Belastungsstruktur handwerklicher Arbeit (Temporal structure of organisation and work load of skilled manual work)* [PhD thesis]. Hamburg: University of Hamburg, 1996.
21 Punnett L, Paquet V. Ergonomic exposures to carpenters and carpentry laborers in tunnel construction. In: A Mital, *et al*, eds. *Advances in occupational ergonomics and safety I (Proceedings of the XIth International Occupational Ergonomics and Safety Conference)*. Amsterdam: IOS Press, 1996:99–104.
22 Erwerb und Verwertung beruflicher Qualifikationen. *BIBB/IAB-Erhebung 1991/92 (Acquisition and use of occupational qualification: BIBB/IAB sSurvey 1991/92)*. Berlin: Bundesinstitut für Berufsbildung, 1995.
23 Von Korff M. Studying the natural history of back pain. *Spine* 1994;**19**:2044S–6S.
24 Riihimäki H. Methodologic problems in assessing health outcome in epidemiologic studies of muskuloskeletal disorders. In: Bundesanstalt für Arbeitsmedizin, ed. *Problems and progress in assessing physical load and musculoskeletal disorders*. Bremerhaven: Wirtschaftverlag NW, 1996: 13–20.
25 Viikari-Juntura E, Raupas S, Martikainen R, *et al.* Validity of self-reported physical load in epidemiologic studies on musculoskeletal disorders. *Scand J Work Environ Health* 1996;**22**:251–9.
26 Bombardier C, Kerr MS, Shannon S, *et al.* A guide to interpreting epidemiological studies on the etiology of back pain. *Spine* 1994;**19**:2047S–56S.

Cohort study of occupational risk factors of low back pain in construction workers

Ute Latza, Wilfried Karmaus, Til Stürmer, Markus Steiner, Axel Neth and Uwe Rehder

Occup Environ Med 2000 57: 28-34
doi: 10.1136/oem.57.1.28