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Most previous studies assessing the association between physical workload and development of low-back pain have used self-reports for exposure. Using company records for quantifying exposure, this study shows that consecutive working days and higher workload are associated with acutely increased low-back pain.

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Key terms: back pain; company record; exposure–response; low-back pain; musculoskeletal disorder; occupational lifting; pain; pain intensity; physical workload; SMS; text message

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Association between occupational lifting and day-to-day change in low-back pain intensity based on company records and text messages

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Objective This study aimed to investigate the association between occupational lifting and day-to-day change in low-back pain (LBP) intensity.

Methods Each day for three consecutive weeks, 95 full-time workers from 51 Danish supermarkets with frequent occupational lifting replied to daily text messages about LBP intensity (scale 0–10). Supervisors at the supermarkets provided information about daily working hours and load (number of different pallets handled) for each worker during the three weeks. Linear mixed models with repeated measures tested the association between variables controlled for LBP during the previous day and various confounders.

Results Workers handled on average 1212 [standard deviation (SD) 861] kg and worked 8.5 (SD 1.8) hours per workday. LBP intensity was higher in the morning after work- compared with non-workdays [difference of 0.55, 95% confidence interval (95% CI) 0.39–0.71]. A cumulative effect of consecutive workdays existed, ie, pain intensity increased approximately 0.30 points per day for up to three days. For three consecutive work- compared with non-workdays, the difference was 0.92 (95% CI 0.50–1.34). Higher load resulted in higher pain intensity in the morning after workdays [0.16 (95% CI 0.02–0.31) per ton lifted], while no effect was found for number of daily working hours.

Conclusion Among workers with frequent occupational lifting, workdays are associated, in a cumulative manner, with increased LBP intensity. Furthermore, an exposure–response association exists between workload and increased LBP intensity. However, the increase in pain intensity was small and future studies should assess whether long-term consequences exist.

Key terms exposure–response; musculoskeletal disorder; physical workload; SMS.

Preventing, treating and managing work-related musculoskeletal disorders remain a challenge in modern society (1). Several types of physical demands in the working environment increase the risk of developing musculoskeletal disorders and sickness absence (2–11). Low-back pain (LBP) is particularly challenging, representing the leading cause of years lived with disability (12). In particular, occupational lifting – which often involves twisting, turning and bending of the back – is associated with increased risk of developing LBP (6) and long-term sickness absence (2). Coenen and coworkers estimated that occupational lifting of loads >25 kg and lifting more frequently than 25 times per day would increase the annual incidence of LBP by 4.3% and 3.5%, respectively (13).

Acute injury often precedes development of chronic pain (14, 15). Researchers have suggested that repetitive work, forceful exertions or awkward lifting may lead to micro-injuries of the tissues that can build up over time developing into chronic musculoskeletal disorders (16–18). Acute pain episodes may represent an underlying micro-trauma that, if repeated frequently, could build up over time and lead to chronic pain by a cumulative trauma injury pathway. However, the transition from acute to chronic pain is complex with interaction between biological, psychological and social factors

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(14, 19, 20). Nevertheless, Nelson-Wong and Callaghan found that transient increases of LBP during two hours of standing were associated with 3-fold increased likelihood of developing clinical LBP during 2-year follow-up (21). Thus, investigating factors associated with day-to-day changes in pain intensity can provide useful information in the early prevention of risk factors contributing to chronic pain.

The majority of previous studies investigating the association between physical workload and development of poor health have used questionnaires to quantify exposure (2–11). However, several methodological limitations exist when using such an approach. For example, when both exposure and outcomes are self-reported, the results may be biased due to common-method variance and other types of bias (22). To counteract this, researchers have developed comprehensive measurement methods using technical equipment such as electromyography and accelerometry to quantify workload during the workday (23, 24). Others researchers have used observational methods to quantify the workload (25). However, both technical measurement and workplace observations are time-consuming, expensive, require expertise, and make the worker aware that he/she is being measured and may thus lead to altered behavior. A cost-effective alternative is to use routinely collected company data to estimate exposure. In spite of the potential benefits of such an approach, only a limited number of studies have used this method. In a study of manual handling during scaffolding, company data on scaffolding parts or the scaffolds volumes represented a valid estimate of the number of manual lifts performed by the individual workers in a team (26). Grajewski and coworkers used company records of flight segments as a proxy for exposure duration in a study of pilots' exposure to cosmic radiation (27). Furthermore, miners' historical exposure to diesel exhaust was estimated using company data on diesel equipment, job tasks, and locations (28).

This study investigates the association between occupational lifting and day-to-day change in LBP intensity. Detailed information about working hours and workload for each worker was obtained from supervisors and company records (exposure) and information about LBP intensity (outcome) was obtained by text message replies from the workers.

Methods

Study population and recruitment

In 2015, we sent a questionnaire on work and health to 203 full-time employees from 51 supermarkets across Denmark. In total, 153 employees replied to the questionnaire and 145 agreed to participate in the project. All respondents fulfilled the inclusion criteria: (i) full-time worker (approximately 37 hours per week in Denmark), and (ii) ≥18 years of age. At 3-week follow-up, 128 employees had replied to ≥10 text messages about LBP intensity out of maximum of 42 (ie, 21 days at 08.00 and 20:00 hours), and the supermarket supervisors had returned information about workload for 107 employees. At the end of the study, complete data – ie, the baseline questionnaire, text message replies about back pain, and supervisor data on workload – were obtained from 95 employees.

Ethics and data protection

According to Danish law, neither questionnaire- nor register-based studies require approval by ethical and scientific committees or informed consent. All questionnaire and text message replies were held confidential as respondents returned their responses directly to the research group. The National Research Centre for the Working Environment has an institutional agreement with the Danish Data Protection Agency about procedures to treat confidential data (journal number 2015-41-4232).

Baseline questionnaire

At baseline, the workers completed a questionnaire about work and health. The following were used as control variables in the statistical analyses: gender, age (continuous variable), seniority (continuous variable), smoking (yes daily, yes once in a while, ex-smoker, no never), body mass index (BMI), psychosocial work environment, and chronicity of LBP. The questions about psychosocial work environment were from the Copenhagen Psychosocial Questionnaire (COPSOQ) (29) and included items on (i) role conflicts, (ii) emotional demands, (iii) influence at work, (iv) work pace, (v) social support, and (vi) support from management. The question assessing chronicity of LBP was "Do you have trouble (pain or discomfort) several times a week which has lasted for more than 3 months in the low back?" with response categories yes or no.

Company records about workload (exposure)

As part of the existing system in the supermarkets, on day-to-day basis, the supervisor has exact records of the number of different pallets of goods delivered as well as working hours for each worker. For the present project, each supermarket supervisor completed information about the number of different pallets handled by each individual worker for each day during the three weeks. Due to factors related to transportation, handling of good etc. the supermarkets also has accurate information on the average weight for each type of pallet. The average weight per pallet for the different types of goods were: milk 260 kg, bread 270 kg, vegetable and fruit 165 kg, grocery 350 kg, meat 220 kg, refrigerated food 345 kg, and frozen food 130 kg. Subsequently, we calculated the total load per day based on the number of different pallets handled by each worker. Each supermarket supervisor also provided day-to-day information about the number of working hours as well as hours seated at the cash register for every worker each day during the three-week period.

Text messages (outcome and control variable)

In three consecutive weeks, the workers replied to daily text messages (SMS) that were sent in the morning (08:00 hours) and evening (20:00 hours) about LBP intensity (outcome). Participants were asked to rate their present pain in the low back on a numerical rating scale of 0 to 10, where 0 is no pain and 10 is worst imaginable pain (30). The majority of replies came within minutes of sending the text message, and as soon as the next message went out the workers could no longer reply to the previous message. Each morning, after replying to the question about pain, the workers also received a question about leisure time physical activity (control variable). Participants were asked to rate their level of leisure time physical activity the day before on a scale of 0–10, where 0=not physically active at all and 10= physically active all the time.

Statistics

Linear mixed models with repeated measures (Proc Mixed, SAS version 9.4, SAS Institute, Cary, NC, USA) determined the association between variables. Supermarket was entered as a random factor to account for clustering. Participant was entered as a repeated factor (21 days) with an autoregressive covariance structure. The estimation method was restricted maximum likelihood (REML) with degrees of freedom based on the Satterthwaite approximation. We did not impute missing data. Instead, the linear mixed-model procedure inherently accounts for missing data, assuming that data are missing at random. The outcome variable was LBP intensity in the morning after the respective exposure days. For the first analysis, work versus non-workdays were compared. The explanatory factor was 0 (non-workday) and 1 (workday). For the second analysis, different two-day combinations of work- and non-workdays were compared. The explanatory factor was 0 (two consecutive non-workdays), 1 (one workday followed by one non-workday), 2 (one non-workday followed by one workday), and 3 (two consecutive workdays). For the third analysis, different three-day combinations of work- and non-workdays were compared. The explanatory factor was 0 (three consecutive non-workdays), 1 (two workdays followed by one non-workday), 2 (one non-workday followed by two workdays), and 3 (three consecutive workdays). All analyses were adjusted for the baseline variables mentioned previously and additionally for LBP intensity (text message reply) during the end of the day prior to the exposure day and leisure-time physical activity (text message reply) during the exposure day. For the fourth analysis, exposures within the workdays were compared. The explanatory factors were total load (kg), working hours and hours seated at the cash register. These explanatory factors were entered as continuous variables in the same statistical model, ie, they were mutually adjusted. Additionally, this analysis was controlled for the same set of confounders as the other three analyses. Results are reported as estimates and 95% confidence intervals (95% CI) for the continuous variables, and least square means and differences of least square means and 95% CI for the categorical variables.

Results

Figure 1 shows the flow of participants through the study. Table 1 presents age and seniority of the participants in the study. Approximately a third of the workers reported chronic LBP. Based on the information from the supervisors, the average working hours per workday were 8.5 (SD 1.8) and the average load handled from the pallets were 1212 (SD 861, range 0–6030) kg per workday.

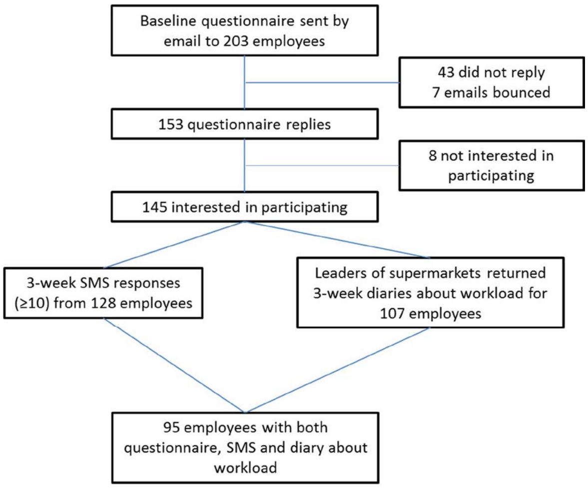

Figure 1. Flow of participants through the study.

Table 1. Demographics, pain and work-related factors. Load and working hours are based on company records (N=95).

	Mean	SD	%
Women			53
Age (years)	30.9	9.2	
Seniority (years)	9.4	7.5	
BMI (kg/m^2)	25.8	4.9	
Smoking			48
Chronic low-back pain			36
Load per day (kg)	1212	861	
Working hours per workday	8.5	1.8	
Hours at the cash register per workday	1.2	1.8	

In the analyses comparing work- and non-workdays (table 2), LBP intensity on a scale of 0–10 was 0.55 (95% CI 0.39–0.71) higher in the morning after workdays compared with the morning after non-workdays. In analyses comparing different combinations of consecutive work- and non-workdays, a cumulative effect of consecutive workdays was seen. Thus, pain intensity was higher in the morning after two consecutive workdays compared with one workday preceded by a non-workday [0.30 (95% CI 0.08–0.51)] and two consecutive non-workdays [0.69 (95% CI 0.45–0.93)]. When one workday was followed by one non-workday, pain intensity the following morning was not higher than in the morning after two consecutive non-workdays. The cumulative effect of workdays became stronger when comparing three consecutive workdays to the other conditions. Thus, pain intensity was 0.92 (95% CI 0.50–1.34) higher in the morning after three consecutive workdays compared with pain intensity in the morning after three consecutive non-workdays. When two workdays were followed by one non-workday, pain intensity in the following morning was not higher than in the morning after three consecutive non-workdays.

In the mutually adjusted analyses of working hours, hours at cash register and workload (table 3), higher occupational load resulted in higher LBP intensity the following morning [0.16 (95% CI 0.02–0.31) per ton lifted]. Daily working hours [0.04 (95% CI -0.03–0.10) per hour working] and hours at the cash register [-0.03 (95% CI -0.10–0.04) per hour working at the cash register] did not significantly influence LBP intensity the following morning.

Discussion

Among workers with frequent occupational lifting, workdays are associated in a cumulative manner with increased LBP intensity. Furthermore, an exposure–response association exists between workload, but not working hours, and increased LBP intensity.

Table 2. Low-back pain (LBP) intensity (scale 0–10) in the morning after workdays compared with non-workdays (first analysis), as well as after different combinations of consecutive workdays and non-workdays (second and third analyses). Controlled for gender, age, seniority, smoking, BMI, psychosocial work environment, chronicity of low back pain, LBP intensity during the end of the day prior to the exposure day, and leisure-time physical activity during the exposure day. [LSM=least square means; 95% CI=95% confidence intervals.]

	LSM	95% CI	LSM difference	95% CI
First analysis				
Non-workdays	1.68	1.38–1.98	Ref	
Workdays	2.24	1.94–2.53	0.55	0.39–0.71
Second analysis				
2 non-workdays	1.54	1.21–1.88	Ref	
1 workday + 1 non-workday	1.63	1.31–1.96	0.09	-0.15–0.33
2 non-workdays	1.54	1.21–1.88	Ref	
1 non-workday + 1 workday	1.94	1.61–2.27	0.39	0.15–0.64
2 non-workdays	1.54	1.21–1.88	Ref	
2 workdays	2.23	1.92–2.54	0.69	0.45–0.93
1 non-workday + 1 workday	1.94	1.61–2.27	Ref	
2 workdays	2.23	1.92–2.54	0.30	0.08–0.51
Third analysis				
3 non-workdays	1.52	1.07–1.97	Ref	
2 workdays + 1 non-workday	1.72	1.37–2.08	0.20	-0.22–0.63
3 non-workdays	1.52	1.07–1.97	Ref	
1 non-workday + 2 workdays	2.16	1.79–2.52	0.64	0.20–1.07
3 non-workdays	1.52	1.07–1.97	Ref	
3 workdays	2.44	2.10–2.78	0.92	0.50–1.34
1 non-workday + 2 workdays	2.16	1.79–2.52	Ref	
3 workdays	2.44	2.10–2.78	0.29	0.00–0.57

LBP intensity was higher in the morning after work- compared with non-workdays. The present findings elaborate on previous longitudinal studies showing that physically demanding work involving occupational lifting increases the risk of LBP (6, 13, 31). On a day-to-day basis, the difference in LBP intensity between work- and non-workdays was approximately 0.55 on a 10-point scale. It may be argued that this change in pain intensity is small and irrelevant. For example, in longitudinal clinical trials a change in pain intensity of <1–2 on a scale of 0–10 is considered clinically irrelevant (32, 33). However, in the present study, the change in pain intensity of 0.55 occurred on a day-to-day basis and not after a prolonged period. Delayed onset muscle soreness (DOMS) is muscle ache involving micro-trauma and inflammation and occurs in the days after unaccustomed high-intensity physical exertion (34). However, the participants of the present study had on average worked 9 years in this type of work and can therefore not be considered unaccustomed to occupational lifting. Nevertheless, highly trained individuals can also experience some degree of DOMS, and the increase in LBP intensity of the present study may therefore reflect DOMS. It can be speculated that the present results indicate micro-traumas of muscles and connective tissues associated with lifting that – if sufficient recovery

Table 3. Contribution of working load, working hours and hours at the cash register to the increase in low-back pain (LBP) intensity (scale 0–10) in the morning after workdays. Values are estimates of the continuous variables from the linear mixed model and 95% confidence intervals (95% CI). The analysis is mutually adjusted for the three explanatory factors and controlled for gender, age, seniority, smoking, BMI, psychosocial work environment, chronicity of LBP, LBP intensity during the end of the day prior to the exposure day, and leisure-time physical activity during the exposure day.

	Estimate	95% CI
Fourth analysis		
Working load, per ton	0.16	0.02–0.31
Working hours, per hour	0.04	-0.03–0.10
Hours at cash register, per hour	-0.03	-0.10–0.04

is not allowed – eventually could build up over time and increase the risk of chronic pain (16–18). However, this should be tested by combining long-term cohort studies with biological laboratory studies (eg, muscle biopsies and microdialysis).

We found a cumulative effect of consecutive workdays for increased LBP intensity. Thus, two consecutive workdays led to higher pain intensity scores than one workday preceded by a non-workday. An additional analysis of three consecutive workdays showed even greater development of pain intensity. Altogether, these results show an increase of pain intensity of approximately 0.3 points per workday when considering up to three days. Interestingly, Coenen and coworkers showed that cumulative low-back loads, based on video observations and force measurements, were prospectively associated with increased risk of LBP in a 3-year follow-up (35). Another long-term study found that transient increases of LBP during two hours of standing were associated with 3-fold increased likelihood of developing clinical LBP during 2-year follow-up (21). Nevertheless, the day-to-day increase of pain intensity in the present study was on average relatively small and more long-term studies should investigate the relevance of acute/transient changes in pain after work for the risk of developing chronic pain.

Interestingly, one non-workday after one workday appeared to be sufficient to recover from the acute increase in pain intensity associated with workdays. That is, when comparing pain in the morning after a non-working preceded by a workday, the pain intensity was not significantly higher than after two non-workdays. A similar result was seen when two workdays followed by a non-workday was compared with three workdays. These results suggest that one non-workday is adequate to recover from up to three workdays and may have relevance for the way in which optimal working weeks are scheduled.

Higher workload was in an exposure–response manner associated with higher pain intensity in the morning after the workday. Thus, for each ton of goods handled, the increase in pain intensity was 0.16 points on a scale of 0–10. Considering the many different ways in which a certain load can be handled and the many other tasks that workers have during a workday, it is not surprising that the association between workload based on the diary registrations and pain development was not stronger. Nevertheless, the results demonstrate the relevance of higher workload for acutely increased LBP intensity. When adjusted for lifting load, longer working hours were not significantly associated with higher pain intensity in the morning following workdays.

This study has both strengths and limitations. A common bias in epidemiological studies investigating the effect of workload on health is that both exposure and outcomes are self-reported. For example, persons with high levels of pain may overestimate their workload, leading to erroneously strong associations between these variables. Further, analyses of associations based on self-reports are in general known to be somewhat influenced by common-method variance where variance is attributable to the measurement method (eg, a questionnaire) rather than the construct the measure represents (22). By contrast, a strength of the present study is that we obtained information on exposure (ie, pallets handled and working hours) on a day-to-day basis directly from company records and supermarket supervisors. The workers then replied to text messages to obtain the outcome measure of pain intensity. The outcome was obtained in the morning after the exposure day and adjusted for pain intensity in the day prior to the exposure day. This design separated information about exposure and outcome both in terms of source and time. Recall bias is another common weakness in epidemiological studies. By contrast, we used repeated text messages for three consecutive weeks to obtain information about pain intensity at present. This method eliminated recall bias. A limitation is that we did not measure the total workload, ie, workers in supermarkets have other tasks than handling pallets. Thus, the noise represented by other work tasks can decrease the estimates towards zero and widen the confidence intervals. Nevertheless, handling goods from pallets represent the major occupational lifting tasks in supermarkets. Another limitation is that the present data did not allow us to estimate the influence of a more traditional 5-day on 2-day off working week on pain intensity. In fact, only 34 of the 95 supermarket workers had an episode of 5 consecutive workdays followed by 2 non-workdays during the 3-week study period.

In conclusion, among workers with frequent occupational lifting, workdays are associated in a cumulative manner with increased LBP intensity. Furthermore, an exposure–response association exists between workload, but not working hours, and increased LBP intensity. However, the increase in pain intensity was small and future studies should assess whether long-term consequences exist.

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