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Physical Workplace Factors and Return to Work After Compensated Low Back Injury: : A Disability Phase-Specific Analysis

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ORIGINAL ARTICLES

Abstract **Author Information** **Authors** **Article Outline** **Outline**

Little is known about predictors of duration of work disability (DOD). This cohort study of 433 workers' compensation claimants estimated DOD for job, injury, and demographic factors during consecutive disability phases using Cox regression analysis. DOD was calculated from administrative records. Results show that DOD increases with the time spent bending and lifting or pushing or pulling heavy objects at work, but it is unrelated to sitting, standing, or vibration. Younger age, longer pre-injury employment, less severe injuries, and a previous back injury predicted shorter disability, the latter factor only during the subacute/chronic disability phases. The effect of injury severity decayed over time. This study demonstrates the usefulness of a phase-specific analysis and shows that physical job and injury factors have a significant and time-varying impact on DOD.

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The existence of a relationship between physical workplace factors and the occurrence of low back pain (LBP) has long been recognized. Among the physical work variables most commonly cited in the literature as risk factors for occupational LBP and injury are heavy physical work, heavy materials handling, heavy or frequent lifting, non-neutral trunk postures (eg, trunk rotation, bending), pushing and pulling, exposure to whole body vibration (motor vehicle driving or other), and prolonged sitting. ^{1,2} In the most comprehensive review of epidemiologic research on the topic, the National Institute for Occupational Safety and Health ² reported the strongest associations between LBP and lifting, other forceful movements such as pushing and pulling, and exposure to whole body vibration. These factors also showed evidence of a dose-response relationship. The findings regarding other factors were less strong, although positive associations were seen between LBP and heavy physical work or awkward postures. The reviewers concluded that the results for static postures are equivocal.

Although specific physical workplace factors have been shown to contribute to the *cause* of LBP and its sequelae of work disability, their effect on the *duration* of work disability (DOD) has rarely been addressed. ³ Researchers modeling DOD using survival analysis techniques have most often used occupation and/or industry as a surrogate for the physical demands of the time-of-injury job. In this regard, four separate research groups reported construction as the highest risk industry for prolonged disability when other factors such as age, sex, and accident or injury type are considered. ^{4–7} Three of these studies dealt with occupational low back injuries ^{5–7}; the fourth population-based study included all compensated injury types. ⁴ With regard to specific occupations, Hogg-Johnson and coworkers found longer durations of work disability among truck drivers, janitors, and construction workers. ⁵ Only one study looked at the physical demands of the job, per se, as a predictor of DOD. ⁸ In their sample of 305 Quebec workers compensated for a first episode of LBP and referred for rehabilitation treatment, Infante-Rivard and Lortie ⁸ found that neither “moving, transferring, or carrying loads” nor “major physical effort” was prognostic of longer disability episodes in univariate or multivariate analyses. However, the lack of quantification of frequency and duration of such activities may have precluded the finding of a significant effect.

Although workers in certain occupations and industries may be at higher risk for longer durations of work disability after a low back injury, it is important to pinpoint exactly which aspects of the work task contribute to an inability or delay in return to work. Indeed, considerable variability exists in the kinds and level of activities engaged in by workers with the same job title, and even more so, within the same industry. 9 Exposure to physical workload on the basis of occupational title is, therefore, too crude a measure for classifying workers into high-risk groups and provides only limited information for the purpose of developing ergonomic interventions. 10,11 The purpose of this article is to investigate the effect of the physical workload of the pre-injury job, measured by time spent in specific activities previously identified as risk factors for low back injury, on the DOD, while controlling for other potential confounders of return to work. This knowledge will aid in the understanding and prevention of chronic (>4 weeks) work disability after low back injury, which accounts for 80% of all workers' compensation costs associated with low back injuries. 12

A second objective of this article is to investigate the possibility of time-dependent effects on DOD. A growing body of research argues for the phase-specificity of certain risk factors. 5,7,13–15 In other words, the impact of a given risk factor on the DOD may change depending on how long the worker has been disabled. Hogg-Johnson and colleagues 5 found that back-injured workers over 30 years of age were at increased risk for longer disability but that the effect of age decayed over time. Other time-dependent factors identified in their study were occupation and type of back injury. Oleinick and coworkers 7 reported different risk factors for the acute (≤ 8 weeks) and chronic (> 8 weeks) phases of work disability after low back injury. During the acute phase, female gender, older age, higher number of dependents, industry (construction), occupation (white collar), and accident type (falls) predicted continued work disability. During the chronic phase, older age, smaller employer size, and higher wage compensation rate predicted DOD. These researchers did not, however, statistically analyze whether differences across the phases were significant. In a review article, Polatin 14 predicted that physical risk factors would be particularly important during the early phase of disability, whereas some psychosocial risk factors, such as mental disorders or the presence of litigation, act predominantly in later phases. For most risk factors, phase-specificity still must be investigated. 13 In this article, we study phase-specificity by distinguishing the effects of predictor variables during the first 30 days of disability (the acute phase) and after 30 days of disability (the subacute/chronic phase).

Methods

Subjects

Study population.

A complete 3-year cohort of 850 compensated low back injury cases was drawn from all workers' compensation claims administered at three district offices of a large workers' compensation insurance carrier in California covering both urban and rural areas in Northern California. The insurer has a client base exceeding 230,000 employers, or about 45% of California's insured employers. The 850 cases were extracted by computer algorithms according to the case criteria (described below) using information contained in three relational databases linked by case claim number: (1) a Master Claims file, containing information on age, sex, date of injury, nature of accident, nature of injury, and dollar amounts of benefits paid to date on each claim; (2) an externally reviewed Medical Payment file, containing individual records of all payments for medical services made on a claim, including date of service, physician diagnosis (*International Classification of Diseases*, 9th revised clinical modification [ICD-9]) codes (up to four per bill), and clinical

procedure and treatment codes; and (3) a Payment History file, containing individual records of all workers' compensation temporary disability, permanent disability, and vocational rehabilitation payments to the worker as well as medical and legal payments. A fourth database containing Employer Policy information was used to obtain information about employer size but was not used in the selection of cases.

Case definition.

Cases consisted of those matching the following administrative and diagnostic criteria: (1) date of injury between January 1, 1994 and December 31, 1996; (2) at least 1 day of temporary disability within 14 days after date of injury; (3) an ICD-9 code indicating a non-traumatic injury relating to the lumbar or sacral region of the spine, according to a list of codes compiled by Cherkin and coworkers. 16 This list contains codes indicative of both "possible" and "definite" spinal injuries in the low back area. Whereas the former include unspecified sites of the spine and ambiguously defined sites (eg, "lumbar or thoracic"), the latter codes pertain explicitly and exclusively to the lumbar or sacral region. ICD-9 codes were used rather than American National Standards Institute injury codes inasmuch as it has been shown that the latter may result in misclassification in identifying low back injuries. 17

Eligible cases had the following time- and diagnosis-dependent criteria: (1) an ICD-9 code indicative of a *definite* LBP diagnosis on any medical bill record of the first physician visit or on any bill record of a physician visit within 14 days after the date of injury; or (2) an ICD-9 code indicative of a *possible* LBP diagnosis on any medical bill record for the first physician visit or on any bill record of a physician visit within 14 days after the first physician visit **and** a *definite* low back ICD-9 code on a bill of a physician visit within 90 days after the date of injury. For these purposes, a physician was defined as a medical doctor, an osteopathic physician, or a chiropractic doctor.

Case exclusion criteria were: (1) an ICD-9 code indicating a vertebral fracture, neoplasm, infection, or inflammatory disease at any point in the life of the claim, and (2) a nature of accident or nature of injury code indicative of a burn, open wound, or fracture. In other words, this study excludes LBP caused by an acute trauma visibly disrupting the integrity of skin or bones. In fact, most of the cases in this study represent so-called "non-specific" or "mechanical" LBP. Only about 3% of cases in this study received the specific diagnosis of "herniated lumbar discs with myelopathy" or "spinal stenosis."

Case selection process.

A complete 3-year set of claims files was available from two of the district offices; for the third office, only the 1994 and 1995 files were available at the time of data collection. Case selection began with the Medical Payment files by extracting all claims that had at least one ICD-9 code indicative of a definite or possible low back diagnosis at *any* time in the life of the claim. The resulting claim numbers were then matched to claim numbers in the current Master Claims files at each of the three district offices. This resulted in 12,632 unique claim numbers. The order of application of inclusion and exclusion criteria to this set of 12,632 claims and the number of cases remaining after each step are as follows: (1) date of injury on or after January 1, 1994: 6828; (2) at least 1 day of temporary disability within 14 days after date of injury: 3166; (3) ICD-9 inclusion criteria: 1076; (4) ICD-9 exclusions: 1044; (5) nature of accident/injury exclusions: 850. The distribution of sociodemographic and administrative case characteristics, injury characteristics, and medical diagnoses has been reported elsewhere. 18

Follow-up interviews.

Of the 850 LBP claims, 721 claimants were selected for a follow-up telephone interview between July and December 1997. The 129 excluded cases: (1) had missing information about their primary treating physician (s) ($n = 26$); (2) had been selected for participation in a pilot test of the telephone survey instrument on the basis of an early date of injury (before April 1, 1994) or late (after December 31, 1996) final temporary disability payment date ($n = 94$); (3) had more than one back injury claim between 1994 and 1996 ($n = 4$); (4) were known to be dead or living outside the country ($n = 2$); or (5) had been misclassified with respect to injury or temporary disability status ($n = 3$). Of the 721 claimants in telephone follow-up, 433 (60%) were interviewed using a survey instrument developed especially for the project. In addition to the workplace variables used in this analysis, the interview collected self-reported information on return-to-work outcomes, perception of medical care received for the injury, current health and functional disability, and worker demographics. Subjects were interviewed at least 6 months after their last temporary disability payment and up to 3.7 years after injury.

Of the 288 claimants not interviewed, 214 could not be located, 31 refused to participate, 14 had a language difficulty, 11 could not complete the interview despite several contacts, 8 did not have a telephone, 7 had died, and 3 denied having had a back injury. An analysis of survey responders ($n = 433$) versus non-responders ($n = 288$) is reported elsewhere. 19 Responders were more often female, older, in professional or machine trades occupations, and had worked longer at the pre-injury job. Median time to the end of disability benefits was slightly lower for responders than non-responders, but differences between the survival curves for DOD were not statistically significant. Because responders and non-responders did not differ significantly in terms of administrative outcome measures, and differences in predictor variables across the groups were controlled for by including these variables in multivariate analyses, we did not expect any important responder bias in our results.

Assessment of Physical Workload

Seven survey questions asked the worker to rate, on a 6-point scale, the amount of time spent at work in various physical activities and postures identified in the literature as risk factors for LBP: lifting heavy objects, pushing or pulling heavy objects, bending, sitting, standing, driving, and working on vibrating surfaces. 2 Questions about static postures involving the whole body (sitting, standing, driving), activities involving high muscular effort, and exposure to vibration have all been shown to offer fair-to-high reliability and validity in self-reported contexts. 10,20–22 Exposure was quantified as the percentage of time spent engaged in each activity, following the format of the Edholm Scale, a well-established physical activity scale:23,24 almost all the time, about three-quarters of the time, about one-half of the time, about one-quarter of the time, a little or about one-tenth of the time, and not at all (see questions in Appendix).

Responses were converted to the scalable predictors: 1 (almost all the time), 0.75, 0.5, 0.25, 0.10, and 0 (not at all), respectively, for the construction of physical workload indices. As a first screening, all pairwise correlations between the items were examined for evidence of association. Results showed moderate-to-strong positive correlations for all pairwise combinations of the heavy lifting, pushing/pulling heavy objects, and bending items ($r^2 = 0.49$ to 0.63 , $P = 0.00$), suggesting overlap between these three activities. These items were negatively correlated with sitting ($r^2 = -0.32$ to -0.36 , $P = 0.00$). Sitting and standing were highly negatively correlated ($r^2 = -0.86$, $P < 0.00$). Sitting also correlated weakly with working on vibrating surfaces ($r^2 = 0.17$, $P = 0.00$). Driving showed a moderate positive correlation with sitting ($r^2 = 0.41$, $P = 0.00$) and working on vibrating surfaces ($r^2 = 0.39$, $P = 0.00$).

To reduce the data to a smaller set of non-overlapping indices that could be used in multivariate analyses, we performed a principal components analysis of the following three groupings of the original seven items, informed by the correlation results and a priori hypotheses: (1) lifting, pushing/pulling, and bending; (2) sitting and standing; and (3) driving and working on vibrating surfaces. The proportion of variance explained by the first principal component for these analyses was 0.70, 0.93, and 0.69, respectively. The coefficients of the first principal components showed approximately equal weightings for lifting, pushing/pulling, and bending (0.60, 0.55, 0.59, respectively), weightings of equal absolute magnitude for sitting and standing (-0.71 and 0.71 , respectively), and equal positive weightings for driving and working on vibrating surfaces (0.71 and 0.71 , respectively).

Given that the first principal component coefficients describe linear combinations of the variables with the greatest variance and that their magnitudes were similar, we decided to combine the scaled scores within each of the three variable groupings to produce three physical workload indices. The first, designated heavy work, is the sum of the worker's scores on the lifting, pushing/pulling, and bending items and ranges from 0 (no exposure to these activities) to 3 (exposure to all three activities, each "almost all the time"). It describes the degree to which the worker engages in active movements that potentially place strain on the lower back. We expect higher heavy work scores to be associated with a lower rate of return to work. The second index, vibration, is the sum of the worker's driving and vibrating scores and ranges from 0 (no exposure) to 2 (driving and vibrating, each "almost all the time"). It captures the degree to which the worker is exposed to whole body vibration, with higher scores indicating a greater risk for not returning to work. The third index, posture, is the difference between the worker's sitting and standing scores. This produces a scale of postural variation from -1 to 1 , with zero representing equal time spent sitting and standing, and extremes of sitting and standing represented by 1 and -1 , respectively. As shown by Magora's 25 early work on occupational risk factors, people working less than 2 hours or more than 6 hours in either standing or sitting positions are at higher risk for LBP than people with more balanced work hours in each position.

Analysis

Survival analysis techniques were used to model the effects on time to return to work of the three physical workload indices—heavy work, posture, and vibration—during two phases of the recovery process: within the first 30 days of disability (acute phase) and beyond the first 30 days of disability (subacute/chronic phase). A 30-day cut point between the phases was chosen because future analyses of physician influence on the return to work process for this cohort will need to separately address the first month after the injury (when choice of primary treating physician is limited for most injured workers in California) from succeeding months. This is just one of the cut points suggested in the literature as the boundary between the acute and subacute phases, which ranges between 3 to 4 weeks, 5 7 weeks, 13,26 and 8 weeks. 7 The second cut point—between the subacute and chronic phases—has been set at 6 months by some 13,26 and 3 months by others. 5 Unfortunately, sample size did not justify analysis of the chronic phase separately from the subacute phase.

Other variables previously identified as prognostic factors for DOD and included in the analysis were: age, sex, injury severity, previous back injury with lost work time, union membership, length of pre-injury employment (<1 year, ≥ 1 year), and employer size. 4,6–8,27,28 Previous back injury and union membership were ascertained during the telephone interview. The source for all other demographic, clinical, and job variables was the workers' compensation insurer's electronic files. Heavy work, posture, vibration, and age were treated as continuous variables. Employer size was a four-level categorical variable based on approximate quantile divisions of employer total yearly payroll amount. All other variables were binary.

For injury severity, we categorized workers into three groups on the basis of the most severe medical diagnosis received during the life of their claim. Workers with ICD-9 codes indicating probable degenerative changes or non-specific backache were categorized as least severe cases; cases with sciatica, possible instability, or herniated lumbar disc without myelopathy were of middle severity; and cases with post-laminectomy syndrome, spinal stenosis, or herniated lumbar disc with myelopathy were most severe. However, because of the similarity in the survival curves of the two higher severity groups and the small number of cases in the most severe group ($n = 16$), we combined the two most severe injury groups into one in our analyses.

The outcome measure for the analysis is time to return to work, operationalized as the total number of compensated workdays calculated from workers' compensation indemnity benefit information in the insurer's electronic administrative files. A proxy for lost work time, it equals the sum of all wage replacement benefits paid to date (temporary disability, permanent disability, and maintenance allowance during participation in a vocational rehabilitation program), divided by the daily temporary disability rate. This gives an estimate of the number of lost workdays compensated during the entire life of a workers' compensation claim. The daily temporary disability rate is used as the unit for measuring lost workdays (as opposed to the daily permanent disability rate or vocational rehabilitation rate) because it reflects the implicit value the workers' compensation system attaches to a full lost workday. We believe that including vocational rehabilitation and permanent disability benefits in the determination of total workdays lost provides a better estimate of actual workdays lost than measures based on temporary disability alone. In earlier reports, we presented this outcome as the best estimate of the number of lost workdays that is derivable from administrative workers' compensation insurance data.^{18,19} We use this administrative measure over a comparable self-reported measure collected retrospectively in our telephone survey to avoid common method bias, ie, the tendency for self-reported measures of both predictor and outcome variables to be biased in the same direction. In the rest of this article, we refer to the end of compensation as a return to work, although we acknowledge that these two outcomes are not necessarily coincident.¹⁹

The survival analysis technique used to model the effect of each independent variable on return to work outcome was the Cox proportional hazards regression analysis. "Survival" analysis has more commonly been used to model undesirable outcomes such as time to death or disease. The term relative "hazard" aptly applies in these contexts to mean the instantaneous risk of death or disease onset at any time point, given that the individual has survived until that time, relative to a baseline reference group. Because we are modeling a positive outcome, time to return to work, we use the term "relative return to work rate" instead of "hazard ratio" when reporting our results. In this context, relative return to work (relRTW) rates greater than 1 reflect shorter durations of disability relative to the reference group. It is also noteworthy that we use a time-to-event outcome that, strictly speaking, is based on cumulative days off work rather than calendar time elapsed since the date of injury to take into account any interspersed work periods. However, during the 30 days after the injury, the correspondence between number of days on disability and calendar time from date of injury to the end of disability was high. Eighty-six percent of interviewed cases had disability gaps of a week or less during this time, and 38% had no gaps at all.

As a first step in the analysis, the effect of each predictor variable on return to work was studied univariately, separately for the acute phase, the subacute/chronic phase, and the phases combined. For the acute phase, the disability experience of all 433 workers was included in the analysis. Workers who had more than 30 compensated days were censored at 30 days so as not to include their post-acute phase experience when determining the influence of the variable during the acute phase. Only the subset of workers whose disability exceeded 30 days was included in models of the effect of each variable during the subacute/chronic phase.

As a second step, we tested the difference between the acute and subacute/chronic phase hazard ratios of each variable by entering each variable and its time-dependent covariate (variable*phase) into the same Cox model, where phase equals 0 for the acute phase and 1 for the subacute/chronic phase. This allows the effect of the predictor variable to change over the follow-up period. A significant value for the time-dependent covariate indicates that the phase-specific hazard ratios significantly differ from each other. This also provides a test of the Cox proportionality assumption, in which the ratio of hazard functions is required to be constant over time for each level of the covariate relative to the baseline when the covariate equals zero.

After conducting the univariate analyses, the third step was to enter all covariates into a single multivariate Cox model. For covariates showing phase-specific effects in the univariate analyses, we included their phase-specific terms. This also addresses any violation of the proportional hazards assumption. All standard errors and confidence intervals (CIs) were constructed using the robust method of calculating the variance-covariance matrix. 29 Analyses were conducted using STATA version 5.0 (Stata Corp, Texas).

Results

Table 1 gives the descriptive statistics for the predictor variables at each phase. The means and proportions for each variable do not differ appreciably from each other across the phases except for injury severity, for which there is a larger percentage of more severe cases during the later phase, and, perhaps, heavy work, which has a higher mean index value during the subacute/chronic phase. Average age was 38 years and most workers were male (about 70%). Most injuries were categorized as less severe (79% and 66%), and about a third of the workers had a previous back injury with lost work time. The majority of workers (about 80%) were non-unionized and had been working at their time-of-injury job for over a year (53% to 55%). The physical workload indices indicated relatively little exposure to vibration in this sample of workers. A mean vibration index of around 0.3 corresponds to 30% of the work time spent driving and/or working on vibrating surfaces. Relatively more work time was spent standing. A mean of -0.5 on the posture index corresponds to 75% of the time spent standing. Average exposure time to lifting, pushing, pulling and/or bending was similar. Mean heavy work indices close to 2 indicate that one of these activities was engaged in at least 75% of the time, and the others from 25% to 100% of the time.

TABLE 1
Demographic, Injury, and Job Characteristics of the Study Sample by Work Disability Phase: 1984-1986 California Low Back Pain Claimant Cohort
(*n* = 425)

Variable	Acute Phase (<i>n</i> = 452)	Subacute/Chronic Phase (<i>n</i> = 214)
Demographic variables		
Age (in years)	37.0 ± 10.8	36.8 ± 9.8
Sex		
Male	30.0	30.0
Female	70.0	70.0
Injury variables		
Injury severity		
Less	79.2	66.8
More	20.8	33.2
Previous back injury		
Yes	32.2	35.0
No	67.8	65.0
Job variables		
Heavy work index	1.88 ± 0.88	1.88 ± 0.88
Vibration index	0.30 ± 0.42	0.30 ± 0.42
Posture index	-0.50 ± 0.25	-0.50 ± 0.25
Union membership		
Yes	19.2	19.2
No	80.8	80.8
Physical employment		
< 1 year	46.8	46.7
≥ 1 year	53.2	53.3
Employment size (total)		
1-99	2.8	2.8
100-999	26.2	27.6
1000-9999	21.2	21.8
10000-99999	29.8	27.8
≥ 100000	20.0	20.0

*Values represent the mean ± standard deviation or percent.

Table 1

The Cox univariate relRTW rates and the 95% CIs for each predictor variable are presented for the acute, subacute/chronic, and for the two phases combined in Table 2. We also give the *P* values for the test of the difference between the relRTW rates of the two phases. Substantial and statistically significant phase-dependent effects were seen for two variables: injury severity ($P = 0.00$) and previous back injury ($p = 0.01$). Workers with less severe injuries were 3.69 times more likely to return to work than workers with more

severe injuries during the acute phase (relRTW rate 3.69, $P = 0.00$, 95% CI 2.32 to 5.87). However, this effect was weaker after 30 days of disability (relRTW rate 1.59, $p = 0.00$, 95% CI 1.10 to 2.14). Having a previous back injury with lost work time did not show a significant effect during the acute phase, but it did show a “protective” effect during the subacute/chronic phase, with a 60% greater probability of return to work (relRTW rate 1.60, $P = 0.00$, 95% CI 1.17 to 2.18). Age and length of pre-injury employment also showed phase-specific effects, but these did not reach statistical significance.

Variable	relRTW rate	P	95% CI
Age	0.90	0.04	0.82 to 0.99
Pre-injury employment > 1 year	1.29	0.01	1.06 to 1.57
Employer size (smallest vs. next smallest)	1.38	0.03	1.04 to 1.84
Heavy work index (one-unit increase)	0.82	0.00	0.73 to 0.92

Table 2

Predictor variables showing significant effects for the combined phase analysis but non-significant differences across phases were age, length of pre-injury employment, employer size, and the heavy work index. For each 10-year increase in age, workers showed a 10% reduced chance of returning to work (relRTW rate 0.90, $P = 0.04$, 95% CI 0.82 to 0.99). Pre-injury employment greater than 1 year increased the likelihood of return to work by 29% compared with employment for 1 year or less at the time-of-injury workplace (relRTW rate 1.29, $P = 0.01$, 95% CI 1.06 to 1.57). Only the difference between the two smallest employer sizes was significant (relRTW rate 1.38, $P = 0.03$, 95% CI 1.04 to 1.84). A one-unit increase in a worker’s heavy work index was associated with an 18% reduced chance of return to work (relRTW rate 0.82, $P = 0.00$, 95% CI 0.73 to 0.92). In other words, the more time at the pre-injury job spent bending and/or lifting, pushing, or pulling heavy objects, the lower the chance of return to work.

Table 3 shows the results of the Cox regression analysis when all of the predictor variables were entered into a single model. Injury severity and previous back injury were the only variables with phase-dependent effects in the univariate analyses. Therefore, we entered two terms for these variables into the model, one for their acute phase effects and the other for their subacute/chronic phase effects. The contribution of all other covariates was limited to their combined phase effect. All variables significant in the univariate analyses were significant in the multivariate analysis, some showing more pronounced effects. Ten-year increases in age were associated with a 15% reduced RTW rate (relRTW rate 0.85, $P = 0.00$, 95% CI 0.76 to 0.94). Workers with less severe injuries showed a more than 4-fold advantage in returning to work during the acute phase than workers with more severe injuries (relRTW rate 4.30, $P = 0.00$, 95% CI 2.60 to 7.10), and an 87% advantage during the subacute/chronic phase (relRTW rate 1.87, $P = 0.00$, 95% CI 1.37 to 2.56). Workers with a previous back injury had a 59% greater chance of return to work during the subacute/chronic phase compared with workers without a previous back injury (relRTW rate 1.59, $P = 0.01$, 95% CI 1.13 to 2.25). Exposure to heavy work (lifting, pushing, pulling, bending) was predictive of a 25% decreased likelihood of return to work (relRTW rate 0.75, $P = 0.00$, 95% CI 0.65 to 0.85, per unit change in the heavy work index), and employment of greater than 1 year showed a 37% advantage over employment for less than 1 year (relRTW rate 1.37, $P = 0.00$, 95% CI 1.11 to 1.68). As in the univariate analysis, workers whose employers had a total yearly payroll between \$150K and \$500K had a higher return to work rate than those whose employers had a lower yearly payroll (relRTW rate 1.32, $P = 0.05$, 95% CI 1.00 to 1.75).

TABLE 3
Multivariate relRTW Rates and 95% CIs for Demographic, Injury, and Job Variables, 1984-1996 California Low Back Pain Claims Cohort (n = 4,027)

Variable	relRTW Rate	95% CI	p
Demographic variables			
Age (10 years)	0.92	0.76-0.99	<.001
Sex			
Male	1.00		
Female	1.12	0.87-1.38	0.32
Heavy work variables			
Heavy objects (bend phase)	1.00		
None	1.00		
Light	0.50	0.30-0.72	<.001
Medium	0.25	0.15-0.38	<.001
Heavy	0.12	0.07-0.18	<.001
Push/pull (bend phase)	1.00		
None	1.00		
Light	0.57	0.37-0.87	<.001
Medium	0.28	0.17-0.45	<.001
Heavy	0.14	0.08-0.22	<.001
Job variables			
Job tenure (years)	0.75	0.60-0.90	<.001
Job tenure squared	0.00	0.00-0.00	0.00
Job tenure cubed	0.00	0.00-0.00	0.00
Job tenure to the fourth power	0.00	0.00-0.00	0.00
Job tenure to the fifth power	0.00	0.00-0.00	0.00
Job tenure to the sixth power	0.00	0.00-0.00	0.00
Job tenure to the seventh power	0.00	0.00-0.00	0.00
Job tenure to the eighth power	0.00	0.00-0.00	0.00
Job tenure to the ninth power	0.00	0.00-0.00	0.00
Job tenure to the tenth power	0.00	0.00-0.00	0.00
Job tenure to the eleventh power	0.00	0.00-0.00	0.00
Job tenure to the twelfth power	0.00	0.00-0.00	0.00
Job tenure to the thirteenth power	0.00	0.00-0.00	0.00
Job tenure to the fourteenth power	0.00	0.00-0.00	0.00
Job tenure to the fifteenth power	0.00	0.00-0.00	0.00
Job tenure to the sixteenth power	0.00	0.00-0.00	0.00
Job tenure to the seventeenth power	0.00	0.00-0.00	0.00
Job tenure to the eighteenth power	0.00	0.00-0.00	0.00
Job tenure to the nineteenth power	0.00	0.00-0.00	0.00
Job tenure to the twentieth power	0.00	0.00-0.00	0.00

relRTW, relative return to work; CI, confidence interval.

Table 3

The results of the multivariate analysis can be used to study relRTW rates for specific subgroups of workers. For example, a carpenter who bends, lifts heavy objects, and pushes or pulls heavy objects almost all of the time (heavy work index $1 + 1 + 1 = 3$) has about half the RTW rate than an office worker who does none of these activities (heavy work index $0 + 0 + 0 = 0$), because the difference between a heavy work index of 3 and 0 translates to a rate of proportional hazards equal to 0.42 (heavy work index cubed = 0.75^3), all else being equal. If, in addition, the carpenter has a more severe injury and the office worker has a less severe injury, all else being equal, the relRTW rate becomes 0.05 ($=0.75^3$), $\times [1/4.30] \times [1/1.87]$). In other words, the carpenter with the more severe injury has a RTW rate that is 20 times lower than the office worker with a less severe injury.

Discussion

This study investigated the impact of specific physical workload factors on the DOD after a compensated low back injury. Our analyses identified a positive relationship between the length of disability and bending, lifting heavy objects, and pushing or pulling heavy objects, while controlling for demographic, injury-related, and other job-related characteristics. Exposure to whole body vibration and prolonged sitting and standing were not related to DOD; in other words, although they have been identified as causal factors for low back injury, they do not seem to be barriers for return to work. On the other hand, forceful movements such as lifting and pushing, along with bending, seem to be strong risk factors for both low back injury and barriers to return to work. These results concur with previous researchers' findings on high-risk occupations for extended work disability. As reported by Hogg-Johnson and colleagues, 5 for example, construction workers, who undoubtedly engage in forceful movements and bending, are among the highest at risk for not returning to work after a back injury.

The differentiation of physical workload factors that play a causal role in the development of LBP from those that also impact the duration of any subsequent work disability has important implications for the development of prevention programs. Injury prevention programs must be informed about risk factors for injury incidence, whereas disability prevention programs must be informed about risk factors for prolonged disability. Indeed, single intervention programs designed to address job factors that are risk factors for both injury and work disability would be the most efficient. On the basis of this study, it seems that jobs involving moving heavy objects and bending may be prime targets for primary prevention programs as well as tertiary prevention in the form of return-to-work programs or modified work programs, 30 because they were associated with longer durations of work disability and have been reported in the literature as the main risk factors for LBP.

Our study also showed that workers with less severe injuries, as determined by doctor's diagnosis, had a more than 4-fold greater chance of returning to work during the acute phase compared with workers with more severe injuries. Infante-Rivard and Lortie 8 found that workers with a medical diagnosis of sprain (a less severe injury) versus intervertebral disc disorder (a more severe injury) were 2.2 times more likely to return to work in a Cox model adjusted for demographic, work, and other clinical factors. These researchers did not conduct a phase analysis, and the relRTW rate obtained in their multivariate analysis is similar to what we found in our univariate analysis of injury severity when the acute and subacute/chronic phases are combined (relRTW rate 2.15). Hogg-Johnson et al 5 and Oleinick et al 7 used type of accident as a proxy for injury severity. In their analyses, fall injuries resulted in longer times on disability than overexertion or bodily reaction injuries, which had a relRTW rate of about 1.4. In both articles, the researchers report a decrease in the effect of accident type over time; in Oleinick's report this effect was no longer significant after 8 weeks of disability.

Although the results of Hogg-Johnson et al 5 and Oleinick et al 7 are not inconsistent with ours nor those of Infante-Rivard and Lortie, 8 we recommend the use of medical diagnostic information, when available, to classify injury severity in preference to information on accident type. On the basis of the aforementioned results, physicians' diagnostic ICD-9 codes seem to have better discriminating power than classifications of injury severity based on accident type. This is plausible for several reasons. Accident data are not necessarily indicative of the actual bodily impact of the accident. In addition, the accuracy of accident data may depend solely on clerical data entry and decision-making during the time of injury report. On the other hand, medical diagnosis, from medical records or abstracted from serial medical billing data, is often based on a series of medical evaluations directly assessing and labeling the severity of the condition.

We know of no other studies that have looked at the prognostic value of a previous back injury with lost work time on the DOD. Infante-Rivard and Lortie 8 tested the univariate effect of a previous back pain episode on return to work and found no significant effect, but they excluded from their sample those cases with previous work loss of 2 or more days. Unexpectedly, in our analysis, a previous back injury with lost work time had a "protective" effect in the subacute/chronic phase. After 30 days of disability, workers with a previous back injury had a 59% higher RTW rate than did workers without a previous episode. This finding is contrary to expectation, given that a previous back injury is a well-known risk factor for future back injuries. 14 However, the workers in our sample who had an earlier back injury had already demonstrated an ability to return to work. In a sense, they are pre-selected as able to cope with a back injury, at least as far as return to work is concerned. On the other hand, the return-to-work capacity of a worker with a first-time back injury has not yet been tested. Whether it is a demonstrated RTW ability, a learning effect regarding self-management of LBP, or some other factor (such as inability to afford an extended work absence) that accounts for the higher RTW rate of previously injured workers after the acute phase requires further exploration.

Apart from the heavy work index, the only other job-related variable found to be predictive of DOD was length of pre-injury employment. Like Infante-Rivard and Lortie, 8 we found that a longer period of employment preceding an occupational back injury resulted in a 30% to 40% greater RTW rate. Infante-Rivard and Lortie set their cut point for length of pre-injury employment at 2 years, whereas we set ours at 1 year. Greater seniority or stronger attachment to a company as a result of longer employment may account for the greater chance of RTW for those employed for at least 1 year before they are injured. Workers with less than 1 year of employment may also have the most hazardous jobs, which makes it more difficult for them to return to work after a back injury.

Another objective of this article was to investigate whether certain factors operate differently during different phases of the course of disability. Among the demographic, injury, and work-related variables tested, only the injury-related variables of severity of injury and previous back injury showed statistically significant phase-specific effects. The effects of age and length of pre-injury employment, however, also changed noticeably across the phases, but these differences were not statistically significant. Severity of injury showed the greatest impact during the first 30 days of disability, when workers with a less severe injury were over 4 times more likely to end disability status compared with more severely injured workers. This effect was attenuated after 30 days to a 59% advantage. The effect of physical workload appears to operate uniformly over the disabling process. Given that the cut point between the acute and subacute phase is still under debate, we performed some exploratory analyses using 8 weeks as the cut point between the acute and subacute/chronic phases instead of 30 days (results not shown). This shift in the upper end of the acute phase did not substantially affect the observed relationships reported here. We conclude that although exact cut points may vary, it is necessary to perform phase-specific analyses to detect possible changes in the strength and direction of associations during the course of work disability.

Overall, our results are in agreement with those of other studies regarding prognostic variables of DOD in LBP patients; younger age, longer history of employment, and less severe injuries have been identified as independent predictors of reduced disability. 4,5,7,8 Hogg-Johnson and colleagues 5 also found a decaying effect of age over time, as did we, although it was not statistically significant, probably owing to our smaller sample size (433 vs 11,762 claims). Hogg-Johnson et al (1994) also found that men had shorter disability durations than women, a finding duplicated by Oleinick et al 7 but only for the first 8 weeks of disability. Like Infante-Rivard and Lortie, 8 we did not find a statistically significant gender effect, although our results are in the same direction. Again, our sample sizes were comparatively small.

Given that exposure to different types and levels of physical workload was assessed retrospectively by interviewing injured workers, we acknowledge the likelihood of measurement errors that would decrease the accuracy of our physical workload estimates. Indeed, the assessment of physical workload by self-report has been shown to be especially problematic for activities involving awkward positions and the lifting of lighter loads, producing low reliability and validity. 10,20–22 For this reason we did not include such activities in our study, instead limiting our questions to those about physical activities that have shown acceptable levels of reliability and validity, ie, simple postures, driving, and moving heavy loads. Still, some of our questions may have failed to adequately measure the intended activity for all respondents. For example, amounts of time spent sitting and driving were highly correlated ($r^2 = 0.41$, $P = 0.00$). Future surveys must more clearly separate non-driving sitting from driving sitting, and standing in a relatively static position (eg, a hairdresser) as opposed to standing up (ie, not sitting) with simultaneous movement (eg, a construction worker).

In summary, prognostic factors for return to work include clinical, job-related, and demographic factors, further illuminating the multifactorial nature of disability. Injury severity, age, length of pre-injury employment, and physical workload, as measured by the amount of bending and lifting, pushing, and/or pulling heavy objects, are all prognostic factors for return to work. Surprisingly, a previous lost-time back injury has a “protective” effect on return to work after 30 days of disability. Our finding that some variables operate differently as a function of length of disability, together with the results from other studies using similar analysis methods, 5,7 underscores the need and utility for phase-specific analyses when studying predictors for DOD. The physical workload results are important in that they suggest specific areas where work interventions, such as modified work, 30 are most needed.

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Appendix

Physical Workload Survey Questions

Questions were asked in the order listed below and used the same response format given for question 1.

- 1. Around the time of your injury, how often did your job at <employer name> involve lifting heavy objects? Did your job involve lifting heavy objects:
 - a. almost all the time
 - b. about [insert amount] of the time
 - c. about half the time
 - d. about [insert amount] of the time
 - e. a little, or about one-tenth, of the time
 - f. not at all.
 - 2. Around the time you were injured, how often did your job involve pushing or pulling heavy objects?
 - 3. Around the time you were injured, how much were you sitting on your job?
 - 4. How much were you standing on your job?
 - 5. How often did your job involve bending?
 - 6. How often did your job involve driving, not including commuting to and from work?
 - 7. How often did your job involve working on vibrating surfaces, for example, on vibrating platforms or in a vibrating vehicle?

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