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Biomechanical and Psychosocial Risks for Low Back Pain

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List of Abbreviations

LBP	Low Back Pain
TLV	Threshold Limit Value
MMH	Manual Material Handling
BMI	Body Mass Index
LMM	Lumbar Motion Monitor
pn	Probability of Normal
NIOSH	National Institute for Occupational Safety and Health
GHQ12	General Health Questionnaire 12-Item Version
KSINEH	knuckle-to-shoulder intermediate number of exertion
FNATLV	Far number of exertions above TLV,
FLINEH	Floor intermediate number of exertions,
KSPATLV	knuckle to shoulder percentage of exertions above TLV,
KSNATLV	knuckle-to-shoulder number above TLV
FPATLV	Far percentage of exertions above TLV
Mngt	management
UNFB1	unfairness boss baseline,
RCONFL	role conflict baseline, WT = Weight

Abstract

Introduction. Low back pain is a common and costly occupational health concern. There are a multitude of risk factors for occupational low back pain including the physical demands of the job, psychosocial characteristics of work, and personal factors. There is a void in the literature examining all three risk factor categories rigorously. Thus, the goal of this project was to examine the physical, psychosocial and personal risk factors that may contribute to occupational low back pain.

Methods. A six-month prospective study was conducted in 9 furniture distribution centers. Sixteen psychosocial risk factors were examined through a self-administered questionnaire. The physical demands of the job were evaluated by a certified professional ergonomist. The ergonomist used the American Industrial Hygiene Association Threshold Limit Value lifting guide to evaluate the jobs. Low back pain was measured using two self-report symptom measures and one objective functional performance measure. Employee evaluations were performed at baseline and six-month follow-up visits. The ergonomic evaluation was performed at baseline.

Results. Three hundred and nine (309) of the initial 471 workers recruited completed the six-month follow-up. There were weak or insignificant correlations among the three outcome measures of low back pain. Correlation analysis showed that a greater number of psychosocial variables were associated with symptoms compared to biomechanical factors. The objective functional performance measure was correlated with a greater number physical demand measures compared to psychosocial variables. The regression analysis of change in objective functional performance illustrated the interaction of the physical and psychosocial demands. In the low physical demand jobs a high job satisfaction score (psychosocial measure) was protective of objective low back function. In the high physical demand jobs low back function deteriorated regardless of the job satisfaction scores. Classification and regression tree analysis as well as logistic regression, were used to examine categories of workers whose low back function "got worse" or "did not get worse" during the study. Psychosocial and personal factor models were developed for low, medium and high physical demands. The most significant psychosocial factor to the model was role conflict for low physical demands, job satisfaction for medium physical demand and unfairness from the boss for high physical demands. Logistic regression models were also constructed for the two pain symptom outcome measures using three categories of 1) stayed the same, 2) moderate symptoms and 3) stayed highly symptomatic. The knuckle to shoulder number of exertions above the threshold limit value was the major physical demands component and role conflict was the most important psychosocial predictor.

Discussion. The low correlations among the three outcome measures suggest that different aspects of low back disorders are being tapped by the different measures. The role of psychosocial measures appears to be greater in pain symptoms measures whereas the role of physical demands appears to be greater in objective functional performance. There is also an interaction between physical demands and psychosocial measures, where in low physical demands situations a high job satisfaction score will be protective of low back function.

Conclusions. The three outcome measures were very different indicators of low back pain. The symptoms outcome measures were influenced more by psychosocial risk factors whereas objective functional performance was influenced more by biomechanical risk factors. The interaction between physical demands and psychosocial factor is complex and dependent upon the outcome measures.

Significant Findings

The first aim of the study was to identify which biomechanical job demands and psychosocial characteristics of work made independent contributions to the risk of low back pain among employees performing manual material handling activities. Change in pain symptoms was influenced by two physical demand measures including the number of exertions above the threshold limit values in the intermediate reach distance with a height between knuckle and shoulder and the number of exertions above the threshold limit value in the height region between the knuckle and shoulder. The psychosocial factors that contribute to the risk of symptoms are role conflict, supervisor social support, unfair treatment from the boss and unfair treatment from upper management. Change in low back function was predicted by several physical demands measures including number of exertions in the intermediate reach distance in the knuckle to shoulder height, number of exertions above the threshold limit value in the far reach distance region, number of exertions from the floor with an intermediate reach, number of exertions with an intermediate reach distance, overall number of exertions, number of exertions above the threshold limit value in the intermediate reach distance, percentage of exertions above the TLV in the close region, overall number of exertions above the TLV, percentage of exertions above the TLV in the knuckle to shoulder far and close reach distance. Change in low back function was predicted by psychosocial factors including unfair treatment from the boss, workload, social support boss, job insecurity, job control, role ambiguity and job strain.

The second aim was to estimate the effect of the interaction of biomechanical and psychosocial factors on the risk of low back pain. The interaction of the biomechanical and psychosocial factors influences the change in objective low back functional. First, in low physical demand jobs high job satisfaction acts to protect low back function whereas in high physical demand jobs there is a decrement in low back function regardless of job satisfaction. Second, in the logistic regression models for low, medium and high physical demands, the psychosocial factors that best predict getting worse change as a function of the physical demands. This indicates that the importance of different psychosocial factors is dependent upon the level of physical demand.

The third aim is to compare the effects of biomechanical demands and psychosocial characteristics of the job on change in low back pain using various indicators of low back pain. The pain symptom outcome measures were influenced more by the psychosocial risk factors compared to the biomechanical demands. The objective low back functional performance outcome measure was influenced more by the biomechanical demands of the job compared to the psychosocial risk factors.

Translation of Findings

Findings from this study can be used to inform intervention efforts to prevent low back pain in the workplace. From the biomechanics side of the equation, minimizing the number of exertions above the threshold limit value in the knuckle to shoulder height region is likely to be most protective. Second, minimizing the number of exertions in the far reach region and floor intermediate reach region will likely reduce the prevalence of low back pain. The application of our findings relevant to psychosocial characteristics of work is more complex. The importance of different psychosocial factors depended on the physical demands of the job and low back pain outcome being predicted. Thus, it is likely that an assessment of the role of psychosocial work characteristics will need to be conducted locally in order to determine the best target intervention. This assessment can be conducted as part of a participatory ergonomics program where employees have input into any changes made to their jobs. Such programs have been shown to improve job satisfaction, which may protect employees with low physical demanding job from low back pain.

Outcome/Relevance/Impact

Low back pain in among employees in furniture distribution centers is caused by both the physical demands of the job and the psychosocial risk factors characteristics of work, as well as by the interaction of the two. The results of this study may be used in the design of furniture distribution center jobs to minimize the risk of low back pain.

Scientific Report

1. INTRODUCTION

Occupationally related low back pain (LBP) represents a major occupational health concern. The etiology of this health problem is complex and poorly understood. At least three types of risk factors are involved: 1) biomechanical demands of the job (e.g., work intensity, static work postures, frequent bending and twisting, lifting); 2) psychosocial characteristics of the job (e.g., time pressures, responsibility, conflict, control, social support); and 3) employee physiological and psychological characteristics.

To date, the role of each risk factor category, in combination with the other risk factors, has not been rigorously investigated. Existing studies of LBP risk have rarely used valid and reliable measures of both biomechanical demands and psychosocial characteristics of the job. In addition, biomechanical and psychosocial risks have tended to be present in similar jobs, making it difficult to disentangle the potential effects of these two types of risk factors. This project was conducted to overcome these shortcomings in the previous literature, by addressing the following specific aims:

(1) To identify the extent to which biomechanical demands and psychosocial characteristics of the job make independent contributions to the risk of LBP among employees performing manual material handling (MMH) activities;
(2) To estimate the potential interaction effects of these two types of occupational exposures on LBP risk (i.e., the extent to which the biomechanical demands of the job influence the magnitude of the contribution of psychosocial job characteristics to overall risk of LBP); and
(3) To compare the effects of biomechanical demands and psychosocial characteristics of the job on LBP risk using various indicators of morbidity (e.g., employee reports of symptoms, biomechanical quantification of trunk motion characteristics, and OSHA 300 log injuries)

1.1 Magnitude of LBP Problem

LBP have been described as one of the most common and significant musculoskeletal problems in the United States, leading to substantial amounts of morbidity, disability, and economic loss (National Research Council & Institute of Medicine, 2001). Back disorders were responsible for half a billion lost work days in 1988 with 22 billion cases reported that year (Guo, 1993; Murphy & Courtney, 2000).

1.2 Risk Factors for LBP

1.2.1 Personal Risk Factors

Several personal or individual factors have been suspected of increasing LBP risk. Age appears to have some relationship to reporting of LBP. Frequency of low back pain symptoms has been observed to reach a maximum between 35 and 55 years of age, whereas lost time from work continues to increase with age (Andersson, 1999). However, prospective studies (e.g., Battie, Bigos, Fisher, Spengler, Hansson, Nachemson, & Wortley, 1990) have reported a significantly higher risk of LBP-related absence in younger workers. It is unclear whether this trend is related to the prevalence of LBP or to the type of work typically assigned to younger employees.

Anthropometric characteristics of LBP patients, such as height and weight, also have been studied extensively. No consistent strong correlation has been found between LBP and stature, weight, and body build, although being tall has been associated with a greater than average risk of back pain in certain investigations (Heliovaara, Knekt, & Aromaa, 1987; Kelsey, 1975a, 1975b). The relative risk was found to be 2.3 in men over 179 cm and 3.7 in women over 169 cm, compared to those who were at least 10 cm shorter (Heliovaara et al., 1987). One case-control study reported a 54% increase in back injury risk with a one unit increase of Body Mass Index (BMI) (Myers, Baker, Li, Smith, Wiker, Liang, & Johnson, 1999).

Cigarette smoking is another individual factor associated with LBP. Compared to lifetime non-smokers, both current and ex-smokers in a British national sample were more likely to have LBP (Palmer, Syddall, Cooper, & Coggon, 2003). Smoking also was associated with the onset of low back pain (Power, Frank, Hertzman, Schierhout, & Li, 2001). Hestbaek, Leboeuf-Yde, Kyvik, & Manniche (2006) found that smoking during adolescence was associated with self-reported low back pain in adulthood.

1.2.2 Biomechanical Risk Factors

1.2.2.1 Biomechanical injury mechanisms

Two major pathways to injury are suspected in occupational LBP. First, *structure loading* is believed to affect the disc and vertebral structures. Annular fibrotic cracks are examples of fatigue crack propagation that can occur when annular tolerances are exceeded. Vertebral end plates, when overloaded, can also form micro-fractures that inhibit disc nutrition. The vertebral bodies themselves can be affected by repetitive lifting as well. Trabecular micro-fractures from cyclic overloading have been well documented and are believed to be a significant LBP risk factor, especially with increasing age. The literature is rich with evidence of a biomechanical linkage to LBP. In general, the root of serious low back pain has been assumed to be discogenic with a mechanical origin (Nachemson, 1975). Videman et al. (1990) confirmed the notion that LBP risk was associated with physically heavy work, such as MMH, by examining the functional spinal units of 86 cadavers whose work and LBP history were known. They found increased degeneration in the spines of those who had performed physically heavy work. This suggests that occupationally related LBP is often associated with biomechanical spine loading.

The second injury pathway involves *muscle overexertion*. When the load imposed upon a specific muscle exceeds the muscle tolerance (muscle strength), a strain occurs. Overexertion to the back occurs frequently in industry and is listed as the cause for 60% of LBP each year. Muscle injuries to the low back typically resolve relatively quickly but account for a very large portion of occupational LBP cases.

1.2.2.2 Biomechanical epidemiology literature

Epidemiological studies of MMH tasks have identified occupational risk factors associated with LBP. They include lifting (e.g., Chaffin & Park 1973; Fymoyer, Pope, Costanza, Rosen, Goggins, & Wilder 1980; Hilderbrandt, 1995; Theorell, Harms-Ringdahl, Ahlberg-Hulten & Westin, 1991); static work postures (e.g.,Theorell et al , 1991; Magora, 1973; Punnet, Fine, Keyserling, Herrin, & Chaffin, 1991); bending and twisting (e.g., Kelsey, Githens, White, Holford, Walther, O'Conner, Ostfeld, Southwick, & Calogero, 1984; Svensson & Andersson, 1989); pushing and pulling (e.g., Hilderbrandt, 1995; Damkot, Pope, & Frymoyer, 1984); and repetition (Chaffin & Park, 1973; Marras, Lavender, Leurgans, Fathallah, Ferguson, Allread, Rajulu 1995; Marras, Lavender, Leurgans, Rajulu, Allread, Fathallah & Ferguson, 1993).

Much of the literature pertaining to LBP has attempted to explain these epidemiologically observed risk factors via biomechanical principles. Retrospective epidemiological relationships simply indicate associations between risk and workplace factors but cannot evaluate causal relationships or injury mechanisms. The benefit of a biomechanical approach is that it may facilitate our understanding of the causal relationship between LBP and work.

The occupational biomechanics literature has attempted to explain many of the epidemiological findings via assessments of the loadings imposed upon the trunk structures under MMH conditions. It is relatively recent that the degree of twisting or bending on the job that increases LBP risk has been quantitatively documented (Marras, Lavender, Leurgans, Fathallah, Ferguson, Allread, Rajulu 1995; Marras, Lavender, Leurgans, Rajulu, Allread, Fathallah & Ferguson, 1993). However, we are just beginning to understand the biomechanical implications of such motions. In addition, studies have not been able to assess how these relationships might change given different psychosocial conditions in the workplace. In a laboratory study Marras, Davis, Heaney Maronitis and Allread (2000) created a stressful and nonstressful work environment and found that workers had greater spine loading during the stressful work conditions. It is hypothesized that, stressful and nonstressful psychosocial conditions occur in occupational setting and that these differences my influence LBP reporting.

Most biomechanical assessments of work situations started with static, sagittally symmetric evaluations of the trunk (Andersson, Jonsson, & Ortengren, 1974; Andersson, Ortengren, & Nachemson, 1977; Andersson, Herberts, & Ortengren, 1976; Andersson, Ortengren, & Nachemson, 1976; Chaffin & Baker, 1970; Ortengren, Andersson, & Nachemson, 1981; Schultz, Andersson, Ortengren, Haderspeck, Nachemson, & Gotegorg, 1982; Schultz & Andersson, 1981). In general, they have focused primarily on the spine compression associated with lifting. More recently, biomechanical investigations attempted to determine the spine loading (Marras & Granata, 1995b; Marras & Mirka, 1989, 1990, 1992; Marras & Sommerich, 1991a, 1991b) and disc tolerances (e.g., Shirazi-Adl, 1989) associated with asymmetric loading of the trunk.

The dynamic trunk motion components of a lift have also been associated with greater spine loading. Biomechanical analyses have shown that dynamic lifting significantly increases the predicted loading of the spine (e.g., Lindbeck & Arborelius, 1991). Increased trunk velocity

during lifting activities has been associated with increased trunk muscle activity and intra-abdominal pressure (Marras, King, & Joynt, 1984; Marras & Mirka, 1990; Marras & Reilly, 1988), increased muscle coactivation (Marras & Mirka, 1990), and increased predicted spine compression (Granata & Marras, 1993, 1995; Marras & Sommerich, 1991a, 1991b).

The nature of spine loading changes significantly with trunk motion (Davis & Marras, 2000). When the speed of trunk motion increases, the viscoelastic properties of the ligamentous spine may act to increase the strain on the spine (e.g., Hukins, Kirby, Sikoryn, Aspden, & Cox, 1990; Keller, Holm, Hansson, & Spengler, 1990), shear and torsional loadings become more prevalent (e.g., Marras & Sommerich, 1991b, Marras & Granata, 1995). Lateral shear forces make the motion segment far more vulnerable to injury than compressive loading (e.g., Shirazi-Adl, 1989; Shirazi-Adl, Ahmed, & Shrivastava, 1986).

These findings suggest that a thorough biomechanical or workplace evaluation of in-vivo occupational LBP risk during MMH should contain several key elements: traditional external moment loading information, three-dimensional spine positioning information, and dynamic motion characteristics of the trunk during MMH activities.

1.2.3 Psychosocial Risk Factors

1.2.3.1 Defining "psychosocial factors"

Over the past decades, increased attention has been paid to the potential role of psychosocial factors in the occurrence of LBP among employees. The literature in this area has defined "psychosocial factors" quite broadly to include (1) psychological characteristics of the employee; (2) exposure to psychosocial work characteristics (e.g., time pressure, mental demands, job control, social support); and (3) job-related attitudes such as job satisfaction (Heaney & Fujishiro, 2006). This all-inclusive approach to psychosocial factors has created a lack of conceptual clarity in the literature. In particular, the important distinction between environmental exposure to psychosocial work characteristics and individual employee vulnerability to the potential adverse consequences of these exposures has not been emphasized. One of the focuses of this study was on exposure to psychosocial work characteristics. These characteristics stem from the way job processes are structured and managed and include the scheduling and pacing of work, the complexity of job tasks, interpersonal aspects of work, the degree of control and autonomy over work tasks afforded the employee, and career concerns such as job insecurity and promotion opportunities (NIOSH, 1999).

Little research has been conducted to describe the psychosocial work characteristics of employees involved in MMH tasks. However, previous work by Karasek and associates (Karasek & Theorell, 1990a) using data from the US Quality of Employment Surveys, by Caplan et al (1980) in the classic NIOSH-sponsored Job Demands and Worker Health study, and by Sparks and Cooper (Sparks & Cooper, 1999) using the Occupational Stress Indicator, suggests that employees involved in MMH may experience (1) few opportunities for decision-making, (2) low levels of autonomy and little influence over how the job is done, (3) above-average workload, (4) little skill and variety on the job, and (5) relationships with supervisors characterized by low levels of support and high levels of undermining.

1.2.3.2 Psychosocial Epidemiological Literature

Several reviews concluded that there is positive evidence for an association between low back pain and job demands (such as time pressure, monotony, workload) social support, and job satisfaction (Ferguson & Marras, 1997; Hoogendoorn, van Poppel, Bongers, Koes, & Bouter, 2000; Linton, 2000). However, other reviews that are more comprehensive (Davis & Heaney, 2000) and focused on prospective cohort studies (Hartvigsen, Lings, Leboeuf-Yde, & Bakketeig, 2004) found inconclusive evidence for associations between psychosocial factors and LBP. When the relationship between psychosocial work characteristics and LBP is adjusted for the effects of biomechanical demands, the relationship tends to be diminished (Davis & Heaney, 2000).

Very few studies have investigated the potential interaction of psychosocial and biomechanical factors in the etiology of LBP. Johansson (1995), in a cross-sectional study of home care workers, found that employees with both a poor psychosocial work environment and high physical workload had the highest prevalence of low back symptoms. However, he did not formally test for the statistical significance of the interaction effect. Thus, it is not clear if a multiplicative (interaction) model fits the data any better than an additive model including the main effects of the two risk factors for LBP. In another cross-sectional study, Devereux et al. (1999) found that workers doing manual work who were exposed to both high physical and psychosocial job demands were at the greatest risk for LBP.

1.3 Methodological Issues

Although the literature does suggest that psychosocial work characteristics are related to LBP, the credibility of the evidence is limited due to methodological problems in many of the studies. This is due particularly to deficiencies in measurement of the independent and dependent variables. In terms of dependent variables, most of the studies reviewed by Davis and Heaney (2000) used only employee self-reports of symptoms as indicators of LBP. Only 7 of the 53 studies reviewed included some kind of clinical LBP assessment. Often, the recall periods for the employee self-reports were too long to result in reliable data. Unvalidated, single-item measures with questionable reliability were not uncommon.

Comparisons between the relationship of psychosocial work characteristics to self-reported symptom outcomes and the relationship of psychosocial work characteristics to more objective, physiological assessments of low back impairment could shed some light on the mechanisms underlying the demonstrated relationships. If the relationship is predominantly due to change in reporting behavior (i.e., employees being more likely to report pain or injury when experiencing a poor psychosocial environment) then the psychosocial characteristics should be most strongly related to the self-report outcomes. However, if the underlying mechanism involves psychosocial factors influencing loadings on the spine, then the relationship of psychosocial characteristics to LBP should also be discernible using physiological indicators. Since most of the existing studies relied solely on self-report measures of LBP, such comparisons have rarely been conducted. The few studies that have been able to investigate this issue have had inconsistent results (Astrand, 1987; Leino & Hanninen, 1995).

Measurement quality of psychosocial work characteristics has been quite uneven across studies. Many of the studies did not use previously validated measures or did not provide information on the measures used. Although there is little evidence that psychosocial work characteristics are stable over time, only two studies (Leino & Hanninen, 1995; Thorbjornsson, Slfredsson, Fredriksson, Koster, Mishelsen, Vingard, Torgen, & Kilbom, 1998) included assessments of psychosocial work characteristics at more than one point in time. Thus, the studies are unable to shed light on the effects of acute versus chronic exposures to poor psychosocial work environments.

Although there are many rigorous, well-conducted studies investigating the role of biomechanical demands in the etiology of LBP, the measurement of biomechanical demands in studies investigating the role of psychosocial work characteristics on LBP has been of dubious quality. Only, Johansson (1995) used measures other than employee self-reports of the frequency of activities such as lifting, repetitive trunk motions, standing and awkward postures. And often these self-report measures were not well-validated, nor of proven reliability.

Many of these studies were cross-sectional or retrospective in design. Such designs are particularly prone to recall bias and selection bias; both biomechanical and psychosocial work characteristics are likely to be affected by the occurrence of LBP. Once an injury has been sustained, a worker may change how he performs the job or may transfer to a less biomechanically demanding job. The occurrence of an injury could also influence relationships with coworkers and supervisors, employee perceptions of job demands, and job satisfaction. The use of self-report measures is particularly suspect when cross-sectional or retrospective studies are conducted. It is likely that the presence of LBP will affect employees' perceptions and reporting of both the biomechanical and psychosocial demands of their jobs. Prospective studies reduce this potential bias.

1.4 Research Questions

With an increased standard of scientific rigor, this study examined (1) the extent to which biomechanical demands and psychosocial characteristics of the job make independent contributions to the risk of LBP among employees performing MMH activities; (2) the potential interaction effects of these two types of occupational exposures on LBP risk (i.e., the extent to which the biomechanical demands of the job influence the magnitude of the contribution of psychosocial job characteristics to overall risk of LBP); and (3) the effects of biomechanical demands and psychosocial characteristics of the job on LBP risk using various indicators of morbidity (e.g., employee reports of symptoms, biomechanical quantification of trunk motion characteristics, and OSHA 300 log injuries).

2. METHODS

2.1 Study Design

This was a prospective cohort study. Baseline data were collected between June 2004 and February 2005, and follow-up data were collected six months later, from November 2004 to June 2006.

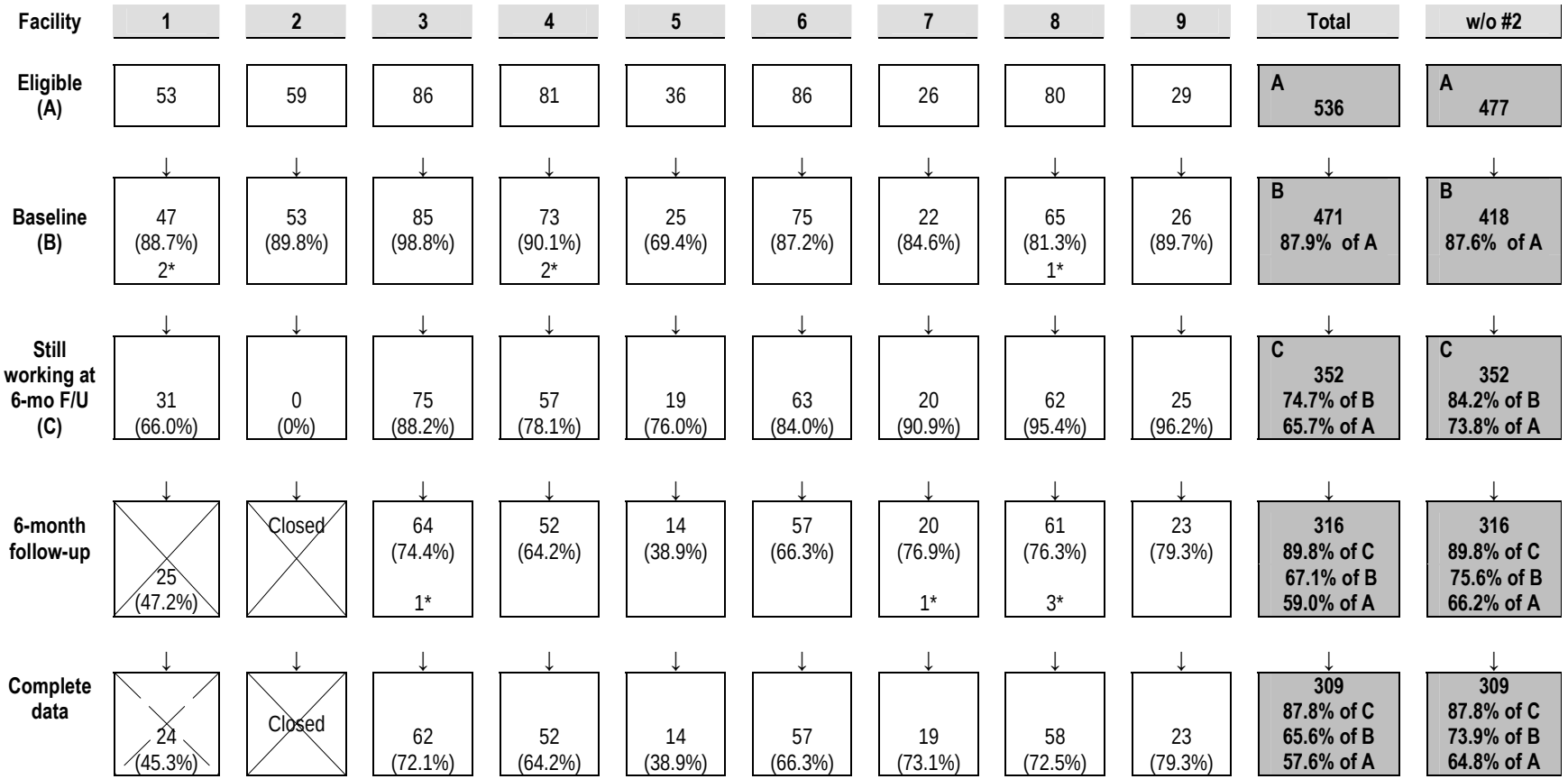
2.2 Sample

Worksites were recruited through the contacts of the Institute for Ergonomics at The Ohio State University. Five companies were recruited for the study. A total of nine furniture distribution centers across five states were suggested by these five companies as study sites.

Baseline data collection included employees in MMH jobs at these nine distribution centers. Figure 2-1 shows the number of employees who participated in the study at each facility. All MMH employees within each facility, 536 in total, were invited to participate in the study. Complete data (i.e., both survey data and quantitative low back functioning data) were obtained from 471 employees at baseline (87.9%). Reasons given for not participating in the baseline data collection included having off-site duties or otherwise not available, being on sick leave or vacation, language barriers that limited the employee's ability to complete the survey, and a small number (n=9) of refusals.

At the six-month follow-up, 309 (65.6%) of the 471 employees who provided both LMM and survey data at baseline completed the study, making an overall response rate of 57.6%. Between baseline and follow-up data collection, two of the nine facilities (#1 and #2 in Figure 2-1) announced their closure. Follow-up data collection at Facility #1 was conducted after the public announcement but before actual closure. Facility #2 closed prior to any follow-up data collection. This resulted in a loss of the entire group of employees (n=59) from Facility #2, as well as a very low follow-up rate in Facility #1. In the other facilities, 50 employees had left their jobs during the course of the study. Thirty-six employees were still working but were not available for data collection. The remaining 7 employees only provided either survey or LMM data at either baseline or follow-up and thus were excluded from further analysis.

The overall response rate is higher when the employees from the facility that closed are excluded: 64.8% of the eligible employees in the eight facilities completed all data collection activities. More detailed information on response rate by facility can be found in Appendix A-1.



* number of participants who completed either survey or LMM only

Figure 2-1. The number of employees (percentage of eligible) and response rates for each facility.

Table 2-1 presents the characteristics of the study participants. The age of the participants ranged from 18 to 77 years, with a median age of 34 years. Almost all study participants were men. About half of the employees identified themselves as Caucasian, a quarter as African American, and one in seven as Latino. Other racial/ethnic backgrounds included Asian, Native American, and Arabic. Sixty percent of the participants did not have more than a high school education. At baseline, the participants had worked for the company from one month to 29 years, with the median being 2.5 years. The median hourly wage was $10.00. This is lower than the national median hourly wage for male MMH workers of $11.43 (Bureau of Labor Statistics, 2004). About two-thirds of the participants were non-smokers. About a third had a BMI within the normal range (BMI between 18.5 and 24.9), but more than 60% were overweight (BMI between 25.0 and 29.9) or obese (BMI of 30.0 or greater).

There was no significant difference between these two groups in terms of age, race/ethnicity, marital status, smoking status, and BMI. Those who provided data at both time points were more likely to have had some education after high school and to be paid a higher wage. They also tended to have worked longer for the company.

TABLE 2-1. Characteristics of the study participants.

	ALL Participants at Baseline (n = 471)		PANEL: both BL and Follow-up (n = 305)		INCOMPLETE: Baseline data only (n = 166)	
Characteristic	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Age						
Younger than 25	96	20.4%	54	17.7%	40	24.8%
25 - 34 years old	143	30.4%	90	29.5%	53	32.9%
35 - 44 years old	108	23.0%	74	24.3%	34	21.1%
45 - 54 years old	96	20.4%	67	22.0%	27	16.8%
55 years or older	27	5.7%	20	6.6%	7	4.3%
Sex						
Male	445	94.5%	280	92.4%	157	96.9%
Female	26	5.5%	23	7.6%	5	3.1%
Race/Ethnicity						
Caucasian/White	254	56.3%	177	60.2%	75	49.0%
African American	105	23.3%	35	11.9%	38	24.8%
Latino/a or Hispanic	65	14.4%	65	22.1%	30	19.6%
Other	27	6.0%	17	5.8%	10	6.3%
Education						
Less than a high school diploma	71	15.2%	39	12.8%	32	20.1%
High school diploma	208	44.5%	129	42.4%	79	49.7%
Some college /vocational training	136	29.1%	97	32.0%	36	22.6%
2-year college degree	31	6.6%	22	7.2%	8	5.0%
4-year college degree	21	4.5%	17	5.6%	4	2.5%

Table 2-1 Continued

Characteristic	ALL Participants at Baseline (n = 471) Freq.	%	PANEL: both BL and Follow-up (n = 305) Freq.	%	INCOMPLETE: Baseline data only (n = 166) Freq.	%
Marital Status						
Never married, currently single	109	23.4%	66	21.9%	42	26.3%
Never married, have a partner	73	15.7%	46	15.3%	26	16.3%
Married	222	47.7%	148	49.2%	72	45.0%
Separated, divorced, or widowed	61	13.1%	41	13.6%	20	12.5%
Tenure with the company						
6 months or less	66	14.3%	40	13.3%	25	15.9%
7 months to 1 year	59	12.8%	31	10.3%	28	17.8%
1 year 1 month to 5 years	188	40.8%	126	42.0%	61	38.9%
More than 5 years	148	32.1%	103	34.3%	43	27.4%
Hourly wage						
Less than $9.00	62	16.2%	34	13.7%	28	21.7%
$9.00 - $9.99	114	29.8%	65	26.1%	48	37.2%
$10.00 - $10.99	53	13.9%	38	15.3%	15	11.6%
$11.00 - $12.99	61	16.0%	47	18.9%	13	10.1%
$13.00 - $14.99	48	12.6%	32	12.9%	15	11.6%
$15.00 or more	44	11.5%	33	13.3%	10	7.8%
Current Smoking Status						
No smoker	304	65.8%	198	66.0%	103	65.2%
10 cigarettes or less	69	14.9%	50	16.7%	18	11.4%
11 – 20	62	13.4%	36	12.0%	26	16.5%
21 – 30	22	4.8%	13	4.3%	9	5.7%
31 or more	5	1.1%	3	1.0%	2	1.3%
BMI						
18.5 or less (underweight)	19	4.3%	10	3.5%	9	5.9%
18.6 – 24.9 (normal)	149	33.4%	107	36.9%	41	27.0%
25.0 – 29.9 (overweight)	177	39.7%	113	39.0%	62	40.8%
30 or greater (obese)	101	22.6%	60	20.7%	40	26.3%

2.3 Data Collection Procedures

Data collection involved three major activities: 1) ergonomic risk assessment of work tasks, 2) biomechanical quantification of trunk motion characteristics using the lumber motion monitor, and 3) employee survey. The details of the measures used in data collection are discussed in the next sections.

2.3.1 Ergonomic risk assessment of work tasks

A Certified Professional Ergonomist identified each facility's primary job categories, through interviews with management and representatives of the labor force. Basic information, including work rates and durations, was gathered. The ergonomist then observed the physical demands required of each job and the work postures assumed by employees. A large, representative sample of objects lifted was measured, as were the forces exerted during pushing or pulling tasks. Information gathered through these efforts was used to calculate the number of exertions that exceeded a threshold for safe MMH, using a well-known and published low-back injury risk assessment tool. The details of these estimations are described in Section 2.5. Observations for each job initially lasted an hour or more; however, since many jobs were similar across facilities, the time needed to assess jobs was reduced as more data were collected.

2.3.2 Biomechanical quantification of trunk motion characteristics

The lumbar motion monitor (LMM), a tri-axial electrogoniometer, was used to quantify dynamic trunk motion performance. The LMM was placed on the subject with a belt and shoulder harness, as illustrated in Figure 2-2. The LMM signal was transmitted to a laptop computer at 60 Hz via a hardwire cable, where the data were stored for future analysis. The LMM's ability to quantify position, velocity, and acceleration in the body's three planes was previously validated (Marras, Fathallah, Miller, Davis, & Mirka, 1992).

Figure 2-2. Lumbar Motion Monitor

The appropriate size LMM was placed on participants. They were instructed to cross their arms in front of them and stand with their feet approximately shoulder width apart for all evaluation tasks. The participants completed six exertions for the functional performance evaluation. For the first task, they were instructed to flex and extend their trunk as fast as they could comfortably, while maintaining their twist position in the zero control zone (+/- 2 degrees). This zone was displayed on the computer screen for the participant to monitor during data collection, as shown in Figure 2-2. The evaluation was explained to the participant as "playing a video game with their back." For the next two tasks, participants were instructed to to twist as far as they felt comfortable clockwise and counter-clockwise. The computer provided visual feedback of the participant's twisting position for these two tasks. The last three tasks were performed randomly, and there was no visual feedback. Participants were instructed to bend side-to-side, twist, and flex and extend their trunks as fast as they could comfortably. Each trial was collected for eight seconds, and the entire testing procedure required approximately 15 minutes per participant. The LMM data were collected from employees one at a time, in a private room, to minimize any distractions.

2.3.3 Employee survey

A self-administered questionnaire was used to measure self-reported LBP symptoms and psychosocial work characteristics. Details about the measures are described in Section 2.4.2 and 2.6. The same questionnaire was administered at baseline and the six-month follow-up. The survey was administered on company time at the participating worksites in small-group settings (five to eight participants at a time). The time needed to fill out the questionnaire varied

considerably, ranging from 20 minutes to over an hour. Participants were paid by the company at their usual rate for the time it took them to participate in the study. They received a t-shirt or a cap as an incentive.

For those with Spanish as their native language, a Spanish version of the survey was provided. The survey was developed by two native Spanish–speaking professionals. The first, who understood the study's purpose and measurement constructs, translated the original English survey into Spanish. The second speaker edited the first translation. During data collection, a native Spanish speaker from the research team assisted in collecting data from Spanish-speaking participants.

For those who had low levels of literacy or had difficulties completing the written survey, data were collected by reading the questionnaire aloud in the employee's preferred language. A small number of the participants needed the questionnaire to be read to them. At the baseline data collection, 11 (18%) of the 62 Spanish speaking participants needed this arrangement while only nine (2%) out of the 408 English speaking participants asked for the questionnaire to be read.

2.4 LBP Outcome Measures

While the state-of-the-art in LBP measurement is improving, no one type of measure can be considered the "gold standard" against which all other measures should be compared. This study therefore used three sources of data to identify episodes of LBP: the clinical lumber motion monitor (LMM), self-reported symptoms, and archival data.

2.4.1 Clinical Lumbar Motion Monitor

The clinical LMM provides biomechanical quantification of trunk motion performance using range of motion, velocity and acceleration. This approach documents the symmetric and asymmetric bending torso *motion characteristics* of a patient and compares these motion characteristics to that of a normal, unimpaired subject population adjusted for age and gender (Marras, Ferguson, Gupta, Bose, Parnianpour, Kim, & Crowell, 1999; Marras, Parnianpour, Ferguson, Kim, Crowell & Simon, 1993). Patients are tested in different torso asymmetries so that different combinations of the trunk's muscles must be recruited to flex and extend the trunk. The motion profile observed during repeated torso flexion and extension at different trunk asymmetries is believed to be a reflection of the trunk's musculoskeletal central control program often called the "central set" (Horak and Diener 1994). For unimpaired subjects, this control program has been well developed over the subject's lifetime. However, for an injured patient, it is thought that this musculoskeletal control program must be adjusted to compensate for limitations in muscle functions, limitations due to structural restrictions, and psychologically determined guarding behavior. This adjusted control program can be reflected by changes in the motion characteristics of the torso.

Two summary measures of low back function were generated from the analysis software. First, the probability of normal (pn), which indicates the low back health status of the individual, was calculated. The pn combines range of motion, velocity, and acceleration from the control task into one overall score that provides an objective quantitative indicator of low back health (Ferguson & Marras, 2004). Pn has a continuous score from 0.0 to 1.0, where the higher the

score, the better the individual's low back health. Pn has been dichotomized at 0.5, with a score less than 0.5 indicating impaired low back performance and a score greater than 0.5 indicating healthy performance. This cut-point offers a sensitivity of 90% and specificity of 92% (Ferguson & Marras, 2004). The clinical LMM measures have been shown to be very consistent with clinical history and tend to show a deficit after symptoms have subsided (Cherniack, Dillon, Erdil, Ferguson, Kaplan, Krompinger, Litt, & Murphy, 2001; Ferguson, Marras, & Gupta, 2000).

The second measure from the clinical LMM protocol is the probability of sincere effort (ps), which indicates if the subject is performing the tasks with his true best efforts (Marras, Lewis, Ferguson, & Parnianpour, 2000). Ps is a continuous measure from 0.0 to 1.0 and is used as an indicator of the trunk motion data's quality. The ps score is calculated by examining the consistency of the phase plane data of higher-order motion characteristics such as velocity and acceleration. The higher the score is, the better the trunk motion. The ps score has also been dichotomized with a sensitivity of 100% and specificity of 90% using a cut-point of 0.6 (Ferguson, Gallagher, & Marras, 2003).

2.4.2 Symptom Questionnaires

The North American Spine Society (NASS) Lumbar Spine Outcome Questionnaire was used to assess low back pain symptms. The NASS Questionnaire consists of 17 questions: six items tap current neurogenic symptoms (e.g., pain in buttock, tingling or numbness in foot or leg), and 11 items measure impairment of activities of daily living (Daltroy, Cats-Baril, Katz, Fossel, & Liang, 1996). Nine of the 11 items for impairment of activities are adapted from the well-known Oswestry Disability Index (Daltroy et al., 1996). All 17 items in the questionnaire were rated on a 6-point scale. A neurogenic symptom score was calculated by averaging six of the questions. A pain and disability score was calculated by averaging the remaining 11 questions (Table 2-2).

2.4.3 Archived data

All participating facilities provided OSHA 300 logs for the year previous to the baseline data collection and up to the six-month follow-up. The logs before the baseline data collection were used to identify preexisting LBP episodes for study participants. The OSHA logs between the baseline and follow-up were used as a supplemental source of information about LBP.

Table 2-2. Self-report measures of LBP symptoms: NASS Neurogenic Symptom Scale and NASS Pain/Disability Scale.

Variable		Item	Response options	Potential range	Cronbach alpha Base-line	Cronbach alpha Follow-up
Neurogenic symptoms[a]	1	Over the past week, how often have you suffered leg pain?	For items 1, 3, and 5 (1) None of the time (2) A little of the time (3) Some of the time (4) A good bit of the time (5) Most of the time (6) All of the time	1 – 6	.93	.93
	2	How bothersome has the leg pain been?				
	3	Over the past week, how often have you suffered numbness or tingling in leg and/or foot?				
	4	How bothersome has the numbness or tingling in leg and/or foot been?	For items 2, 4, and 6 (1) Not at all bothersome (2) Slightly bothersome (3) Somewhat bothersome (4) Moderately bothersome (5) Very bothersome (6) Extremely bothersome			
	5	Over the past week, how often have you suffered weakness in leg and/or foot?				
	6	How bothersome has the weakness in leg and/or foot been?				
Pain and disability[a] (Oswestry Scale)	1	In the past week, how often have you suffered low back and/or buttock pain?	(1) None of the time (2) A little of the time (3) Some of the time (4) A good bit of the time (5) Most of the time (6) All of the time	1 – 6	.89	.89
	2	How bothersome has the low back and/or buttock pain been?	(1) Not at all bothersome (2) Slightly bothersome (3) Somewhat bothersome (4) Moderately bothersome (5) Very bothersome (6) Extremely bothersome			
	3	In the past week, how has pain affected you when you get dressed?	(1) I can dress myself without pain. (2) I can dress myself without increasing pain. (3) I can dress myself but pain increases. (4) I can dress myself but with significant pain. (5) I can dress myself but with very severe pain. (6) I cannot dress myself due to pain.			
	4	In the past week, how has pain affected you when you lift something?	(1) I can lift heavy objects without pain. (2) I can lift heavy objects but it is painful. (3) Pain prevents me from lifting heavy objects off the floor, but I can lift heavy objects if they are on a table. (4) Pain prevents me from lifting heavy objects off the floor, but I can lift light to medium objects if they are on a table. (5) I can only lift light objects due to pain. (6) I cannot lift anything due to pain.			

[a] Deltroy et al. (1996)

(Table 2-2 continued)

Variable		Item	Response options	Potential range	Cronbach alpha	
					Base-line	Follow-up
Pain and disability[a] (Oswestry Scale)	5	In the past week, how has pain affected you when you are walking and running?	(1) I can walk or run without pain. (2) I can walk comfortably, but running is painful. (3) Pain prevents me from walking more than 1 hour. (4) Pain prevents me from walking more than 30 minutes. (5) Pain prevents me from walking more than 10 minutes. (6) I am unable to walk or can walk only a few steps at a time.			
	6	In the past week, how has pain affected you when you are sitting?	(1) I can sit in any chair as long as I like. (2) I can only sit in a special chair for as long as I like. (3) Pain prevents me from sitting more than 1 hour. (4) Pain prevents me from sitting more than 30 minutes. (5) Pain prevents me from sitting more than 10 minutes. (6) Pain prevents me from sitting at all.			
	7	In the past week, how has pain affected you when you are standing?	(1) I can stand as long as I want. (2) I can stand as long as I want but it gives me pain. (3) Pain prevents me from standing more than 1 hour. (4) Pain prevents me from standing more than 30 minutes. (5) Pain prevents me from standing more than 10 minutes. (6) Pain prevents me from standing at all.			
	8	In the past week, how has pain affected you when you sleep?	(1) I sleep well. (2) Pain occasionally interrupts my sleep. (3) Pain interrupts my sleep half of the time. (4) Pain often interrupts my sleep. (5) Pain always interrupts my sleep. (6) I never sleep well.			

(Table 2-2 continues)

Variable		Item	Response options	Potential range	Cronbach alpha Base-line	Cronbach alpha Follow-up
	9	In the past week, how has pain affected your social and recreational life?	(1) My social and recreation life is unchanged (2) My social and recreational life is unchanged, but it increases pain. (3) My social and recreational life is unchanged, but it severely increases pain. (4) Pain has restricted my social and recreational life. (5) Pain has severely restricted my social and recreational life. (6) I have essentially no social and recreational life because of pain.			
	10	In the past week, how has pain affected your traveling?	(1) I can travel anywhere. (2) I can travel anywhere but it gives me pain. (3) Pain is bad but I can manage to travel over 2 hours. (4) Pain restricts me to trip of less than 1 hour. (5) Pain restricts me to trip of less than 30 minutes. (6) Pain prevents me from traveling.			
	11	In the past week, how has pain affected your sex life?	(1) My sex life is unchanged. (2) My sex life is unchanged, but causes some pain. (3) My sex life is nearly unchanged, but it is very painful. (4) My sex life is severely restricted by pain. (5) My sex life is nearly absent because of pain. (6) Pain prevents any sex life at all.			

2.5 Biomechanical job assessment

The physical requirements for each job that participants performed were measured and evaluated. The specific measurements taken were based on a comprehensive literature review of those workplace factors showing a strong link to LBP (National Research Council & Institute of Medicine, 2001). These factors were: amount of MMH required, load moment (the product of a load's weight and the distance from the spine at which it was applied), frequency of bending and twisting, and the amount of heavy physical work. This review also found a strong link between LBP and whole-body vibration; however, participants in this study were not exposed to this type vibration, so it was not measured.

The workplace factors measured for each of the jobs were:

- Frequency – The number of times per hour that the job required a physical exertion (e.g., lift, lower, push, pull, carry).
- Duration – The amount of the work day that the physical exertions were performed.
- Force – The level of the force required to perform the exertion, or the amount of weight that was lifted.
- Horizontal Distance during Force Application – The distance from one's spine to the hands when the exertion was begun.
- Vertical Location during Force Application – The distance from the ground at which the force was exerted.

Each of these factors is linked to workplace measures associated with LBP. The frequency and duration variables indicated the amount of MMH required for each of the jobs. Force provided an assessment of physical work level. The product of force and horizontal distance during force application determined load moment about the spine. Vertical location of the load during handling was an indirect indicator of the type of postures required for the job.

Frequency and duration information was obtained from company records and employee interviews. Productivity data for each facility (i.e., numbers of items received, assembled, shipped) were gathered across a twelve-month period, to account for seasonal fluctuations. This information, combined with the numbers of employees performing each job, was used to estimate the amount of materials handling required per worker, on an hourly basis. Discussions with managers and the participants provided details regarding whether the materials handling for each job took place for a large percentage of the day (e.g., more than two hours per day) or less frequently (e.g., less than two hours daily).

Items lifted or carried were weighed using a heavy-duty scale, and the effort needed to push or pull heavy items was measured using a Chatillon® force gauge. For many jobs evaluated in these furniture industry and distribution center facilities, the products handled were quite variable. That is, employees moved items that differed considerably in size, shape, and weight (e.g., ottomans, chairs, sofas, armoires, mattresses). Thus, each job was observed for a considerable length of time, to assess a representative sample of job physical requirements.

The horizontal and vertical locations at which the physical exertions occurred (relative to the body) were determined using a tape measure and visual observations. Forces exerted by the spine were categorized as being either "close" (less than 30 cm), an "intermediate distance" (between 30 cm and 60 cm) from the spine, or "extended" (more than 60 cm from the spine). The vertical location of the exertions was taken with respect to the employee (i.e., between the floor and mid-shin, between mid-shin and the knuckles, between the knuckles and the shoulders, or above the shoulders).

Data from the five workplace factors were consolidated and compared against threshold limit values (TLVs) determined by the ACGIH (American Conference of Governmental Industrial Hygienists, 2001). TLVs are weight limits for a variety of lifting conditions under which it has been shown that nearly all employees can be exposed without developing low-back or shoulder disorders associated with repetitive physical exertions. For each job, the typical number of total

exertions performed hourly was computed, as was the number of these that were above the computed TLV.

2.6 Psychosocial job assessment

Subscales of the National Institute for Occupational Safety and Health (NIOSH) Generic Job Stress Questionnaire (GJSQ) were used to measure an array of specific job demands and work organization characteristics (Hurrell & McLaney, 1988). The GJSQ has been widely used in occupational stress research. The GJSQ scales were selected by researchers at NIOSH, based on their demonstrated reliability and their construct or predictive validity (Hurrell, Nelson, & Simmons, 1998).

Employees' assessments of six types of job characteristics were measured: *quantitative workload* (e.g., "your job requires you to work very fast"), *role conflict* (i.e., "you receive conflicting requests from two or more people"), *role ambiguity* (e.g., "you know exactly what is expected of you on the job"), *mental demands* (e.g., "your job requires a great deal of concentration"), *task control* (e.g., "how much influence do you have over the order in which you do tasks at work?"), and *social support* ("How much can your boss/other people be relied on when things get tough at work?").

In all questions, employees were asked to report the extent to which they were exposed to or experienced certain job demands or work organization characteristics, rather than asking the employees to report how problematic or distressing certain aspects of their work environments were. Questions pertaining to quantitative workload and role conflict were asked in terms of frequency (e.g., "How often is there a great deal to be done?", and response options were "Never" (1), "Rarely" (2), "Sometimes" (3), "Often" (4), and "Almost all the time" (5)). Questions on role ambiguity, mental demands, and task control were asked in terms of intensity (e.g., "To what extent does your work need your undivided attention?", and response options were "Not at all" (1), "Just a little" (2), "A moderate amount" (3), "Quite a bit" (4), and "A very great deal" (5)).

In addition to these well-studied psychosocial factors, the questionnaire included a measure of fairness in the work place. This measure was newly designed for the study, based on a previous qualitative study (Heaney & Joarder, 1999). It measured supervisor fairness, management fairness, and wage fairness. Table 2-3 shows all items and response options used in assessing psychosocial work characteristics.

Table 2-3. Questionnaire items for psychosocial characteristics of work, response options, and Cronbach alphas.

Variable		Item	Response options	Potential range	Cronbach alpha	
					Base-line	Follow-up
Workload [a]	1	Your job requires you to work very hard	(1) Never	1 - 5	.73	.75
	2	Your job requires you to work very fast	(2) Rarely			
	3	A great deal to be done	(3) Sometimes			
	4	Your job leaves you with little time to get things done	(4) Often			
			(5) Almost all the time			
Role Conflict [a]	1	Do things that are apt to be accepted by one person and not accepted by others	(1) Never	1 - 5	.81	.80
	2	Do things on the job that are against your better judgment	(2) Rarely			
	3	Feel pressure to do things that you think may not be best	(3) Sometimes			
	4	Receive conflicting requests from two or more people	(4) Often			
	5	Too many different things to do at work	(5) Almost all the time			
	6	Have to bend or break a rule or policy to carry out an assignment				
Role Ambiguity [a]	1	Know exactly what is expected of you on your job (R)	(1) Not at all	1 - 5	.72	.81
	2	Have a clear explanation about what has to be done on your job (R)	(2) Just a little			
	3	Know your job responsibilities (R)	(3) A moderate amount			
	4	Clear, planned goals and objectives for your job (R)	(4) Quite a bit			
			(5) A very great deal			
Mental Demands [a,b]	1	*Watch for things going wrong	(1) Not at all	1 - 5	.76	.76
	2	*Your job requires a great deal of concentration	(2) Just a little			
	3	*Your work need your undivided attention	(3) A moderate amount			
	4	*Keep your mind on your work at all times	(4) Quite a bit			
	5	*React quickly to prevent problems	(5) A very great deal			
	6	*Job require you to remember many different things				
	7	*Keep track of more than one thing at a time				
Job security	1	How likely is it that, if you want it, you can keep you job for the next year?	(1) Extremely likely	1 - 5	.50	.72
	2	How likely is it that you will lose your job because of layoffs or downsizing during the next year?	(2) Very likely			
			(3) Somewhat likely			
			(4) A little likely			
			(5) Not at all likely			

[a] Adapted from NIOSH GJSQ (J. J. Hurrell, Jr. & M. A. McLaney, 1988)

[b] Adapted from the Job Demand and Control Scale (Jackson, Wall, Martin, & Davids, 1993)

(Table 2-3 continued)

Variable		Item	Response options	Potential range	Cronbach alpha	
					Base-line	Follow-up
Employment security	1	If you lost your current job, how likely is it that you could find a comparable job elsewhere?	(1) Extremely likely (2) Very likely (3) Somewhat likely (4) A little likely (5) Not at all likely	1 - 5	.48	.46
	2	If you lost your current job, how likely is it that you would be employed elsewhere within a short time?				
	3	If your company went out of business, how likely is it that you would have to learn new skills to be employable?				
Social Support From boss/ coworkers[a]	1	How much dose your boss/do other people at work go out of his/their way to do things to make your work life easier for you?	(1) Not at all (2) A little (3) Somewhat (4) Very much	1 - 4	Boss .85 Cowor ker .77	Boss .86 Cowor ker .72
	2	How easy is it to talk with your boss/ other people at work?				
	3	How much can your boss/ other people at work be relied on when things get tough at work?				
	4	How much is your boss/ are other people at work willing to listen to your personal problems?				
Job Control[a]	1	How much influence do you have over the variety of tasks you do at work?	(1) Not at all (2) Just a little (3) A moderate amount (4) Quite a bit (5) A very great deal	1 - 5	.73	.78
	2	How much influence do you have over the order in which you do tasks at work?				
	3	How much influence do you have over the amount of work you do?				
	4	How much influence do you have over the pace of your work, that is, how fast or slow you work?				
	5	To what extent can you do your work ahead and take a short rest break during work hours?				
	6	In general, how much influence do you have over how you do your work?				

[a] Adapted from NIOSH GJSQ (J. J. Hurrell, Jr. & M. A. McLaney, 1988)

(Table 2-3 continued)

Variable		Item	Response options	Potential range	Cronbach alpha Base-line	Cronbach alpha Follow-up
Fairness at work *"To what extent does your immediate supervisor…?"* *"To what extent does upper management …?"*	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	Appreciate extra effort from employees [c] Appreciate employees' hard work [b] Praise employees for good work [b] Notice if an employee does the best job possible Play favorites [b] Treat employees differently based on their race Treat employees like children [b] Treat employees with respect [b] Yell at employees [b] Lie to employees [b] Available to help when an employee has a problem [c] Understand when an employee is absent due to a personal problem [c] willing to help employees when they need a special favor [c] Care if employees are satisfied with their jobs [c] Concerned about employee well-being [c] Ignore employees' suggestions [b] Care about employees' opinions Disregard the consequences of decisions on employees [c] Ignore employees complaints [c] Take advantage of employees if given opportunities [c] The organization cares more about making a profit than about employee well-being [c] Employees are blamed for things that are not their fault or are outside their control Make unreasonable demands of employees	(1) Not at all (2) Just a little (3) A moderate amount (4) Quite a bit (5) A very great deal	1 - 5	supervisor .95 management .95	supervisor .95 management .95
Wage Fairness *"To what extent does upper management …?"*	1 2	Management is concerned about paying employees what they deserve [c] If the company earned a greater profit, upper management would consider increasing employee salaries [c]	(1) Not at all (2) Just a little (3) A moderate amount (4) Quite a bit (5) A very great deal	1 - 5	.77	.83

[b] Adapted from the Perceptions of Fair Interpersonal Treatment Scale (Donovan, Drasgow, & Munson, 1998)
[c] Adapted from the Scale of Perceived Organizational Support (Eisenberger, Huntington, Hutchison, & Sowa, 1986)

Along with the employees' assessments of psychosocial characteristics of work, global job attitudes and employee well-being were measured (Table 2-4). The Stress-in-General scale (Stanton et al., 2001) was used as a measure of perceived job stress. The scale consists of 12 adjectives (e.g., hectic, nerve-wracking), and employees were asked to indicate whether each item described their job. Items were rated on a three-point scale: "yes (=3)," "no (=0)," and "I can't decide (=1.5)."

For job satisfaction, a four-item scale was adapted from the GJSQ (Hurrell.& McLaney, 1988). The items focused on global job satisfaction (e.g., whether or not the respondent would take the same job if he could choose) as opposed to specific facets of the job (i.e., pay, work schedule).

The General Health Questionnaire 12-item version (GHQ12) was used to assess respondents' psychological well-being (Goldberg & Williams, 1988). Although the GHQ was originally developed as a screening tool to detect psychiatric disorders, it has been validated with general population samples (McDowell & Newell, 1996). The 12-item US version was used, which addressed depression, anxiety, and disturbance in social functioning. Four response options were coded as follows: better than usual (0), same as usual (0), less than usual (1), and much less than usual (1). The responses for the 12 items were summed and used to create an overall score.

Table 2-4. Global job attitudes and employee well-being.

Variable		Item	Response options	Potential range	Cronbach alpha	
					Base-line	Follow-up
Job satisfaction [a]	1	Knowing what you know now, if you had to decide all over again whether to take the type of job you now have, what would you decide?	I would… (1) decide without hesitation to tale the same type of job (1.5) Have some second thoughts (2) Decide definitely NOT to take the same type of job	1 – 2	.82	.79
	2	If you were free right now to go into any job you wanted, what would your choice be?	I would … (1) Take the same job (2) take a different job			
	3	If a friend of yours told you he was interested in working in a job like yours, what would you tell him?	I would … (1) strongly recommend it (1.5) have doubts about recommending it (3) advice against it			
	4	All in all, how satisfied would you say you are with your job?	(1) Very satisfied (1.66) Somewhat satisfied (2.33)Not too satisfied (2) Not at all satisfied			
Global job stress [c]		*"Think of your job in general. All in all, what is it like most of the time?"*				
	1	Demanding	(1) Yes (3) No (1.5)I cannot decide	1 – 3	.89	.89
	2	Pressured				
	3	Hectic				
	4	Calm				
	5	Relaxed				
	6	Many things stressful				
	7	Pushed				
	8	Irritating				
	9	Under control				
	10	Nerve-wracking				
	11	Hassled				
	12	Comfortable				

[a] Adapted from NIOSH GJSQ (J. J. Hurrell, Jr. & M. A. McLaney, 1988)
[b] Adapted from the Job-in-General Scale (Stanton, Balzer, Smith, Parra, & Ironson, 2001)

(Table 2-4 continued)

Variable		Item	Response options	Potential range	Cronbach alpha	
					Base-line	Follow-up
Psychological well-being [d]	1	Over the past few weeks, have you been able to concentrate on whatever you're doing?	For Item 1, (1) Better than usual (2) Same as usual (3) Less than usual (4) Much less than usual	1 – 4	.79	.77
	2	Over the past few weeks, have you lost much sleep due to worry?				
	3	Over the past few weeks, have you felt that you are playing a useful part in things?	For Items 2, 5, 6, 9,and 10, (1) Not at all (2) No more than usual (3) A little more than usual (4) Much more than usual			
	4	Over the past few weeks, have you felt capable of making decisions about things?				
	5	Over the past few weeks, have you felt constantly under strain?	For Items 3, 4, 7, 8, and 12, (1) More so than usual (2) Same as usual (3) Less so than usual (4) Much less than usual			
	6	Over the past few weeks, have you felt you couldn't overcome your difficulties?				
	7	Over the past few weeks, have you been able to enjoy your normal day-to-day activities?				
	8	Over the past few weeks, have you been able to face up to your problems?				
	9	Over the past few weeks, have you been feeling unhappy and depressed?				
	10	Over the past few weeks, have you been losing your confidence in yourself?				
	11	Over the past few weeks, have you been thinking of yourself as a worthless person?				
	12	Over the past few weeks, have you been feeling reasonably happy, all things considered?				

[a] Adapted from NIOSH GJSQ (J. J. Hurrell, Jr. & M. A. McLaney, 1988)

Surveys conducted in English and in Spanish resulted in different levels of internal consistency in some of the measures. As shown in Table 2-5, baseline responses from Spanish-speaking employees had low internal consistency for a number of the measures, mainly those assessing psychosocial job characteristics (i.e., workload, role conflict, role ambiguity, job insecurity, employment insecurity, and job satisfaction). Responses from English-speaking employees had acceptable levels of internal consistency, except for job insecurity and employment insecurity. At follow-up, the Spanish-speaking employees who remained in the study provided data with higher internal consistency. Still role ambiguity, job insecurity, and employment insecurity did not have an acceptable level of internal consistency of 0.70 for participants who completed the questionnaire in Spanish. Internal consistency of the self-report symptoms measures were good for both English speakers (Cronbach alpha = .81) and Spanish speakers (.75).

TABLE 2-5. Cronbach alpha statistics for psychosocial work characteristics by language

	Baseline				Follow-up			
	English		Spanish		English		Spanish	
Variable	N	Cronbach Alpha	N	Cronbach Alpha	N	Cronbach Alpha	N	Cronbach Alpha
Workload	404	0.74	61	0.58	280	0.72	32	0.87
Role conflict	403	0.81	60	0.67	281	0.79	30	0.85
Role ambiguity	400	0.72	58	0.62	277	0.82	31	0.58
Mental demands	401	0.74	58	0.73	278	0.77	30	0.71
Job insecurity	401	0.46	49	-0.04	278	0.75	31	0.30
Employment insecurity	404	0.52	51	0.21	280	0.46	31	0.15
Job control	401	0.73	57	0.79	276	0.76	31	0.86
Social support (boss)	404	0.87	54	0.71	278	0.86	31	0.89
Social support (coworkers)	405	0.78	55	0.74	281	0.72	31	0.71
Unfairness (boss)	381	0.95	46	0.86	268	0.95	28	0.90
Unfairness (management)	368	0.95	42	0.85	265	0.96	26	0.94
Unfairness (wage)	389	0.77	48	0.80	277	0.83	30	0.91
Job satisfaction	401	0.81	56	0.62	275	0.76	32	0.70
Global job strain (Stress-In-General)	399	0.89	61	0.84	280	0.88	28	0.92
Mental health problems (GHQ-12-continuous)	394	0.79	52	0.81	277	0.78	29	0.78
NASS Neurogenic Symptom scale	392	0.81	55	0.86	281	0.83	29	0.94
NASS Pain and Disability scale	379	0.88	51	0.76	281	0.81	29	0.75

3. DESCRIPTIVE RESULTS

3.1 Descriptive statistics for independent variables

3.1.1 Psychosocial work characteristics and attitudes toward the job

Table 3-1 presents descriptive statistics for the psychosocial work characteristics for all respondents at baseline (n=471) as well as those who provided data at both baseline and follow-up (n=305). In general, scores were distributed over the full-range of the scales, and mean scores were near the middle of the potential scoring range. However, mean scores were relatively high for workload and unfairness (wage), and they were relatively low for role ambiguity and job insecurity. Mean scores and standard deviations were fairly stable overtime.

Descriptive statistics for the measures of job attitudes and well-being are shown at the bottom of Table 3-1. The mean score of job satisfaction is slightly higher than the mid-point of the scale, and the mean score of global perceived job stress is slightly lower than the mid-point of the scale. The General Health Scale (GHQ12) can be treated either as continuous (i.e., sum of the 12 items) or dichotomous (i.e., cut-off between 4 and 5). When treated as a continuous variable, higher scores indicate less mental health. When treated as dichotomous, scores of five and higher indicate a clinically meaningful level of mental health symptoms (Goodchild & Duncan-Jones, 1985). As shown in Table 3-1, the mean score for GHQ12 was lower than the clinical threshold. However, roughly one-third of the participants scored five or higher.

TABLE 3-1. Descriptive statistics for psychosocial work characteristics, global job attitudes, and employee well-being

	Baseline										Follow-up				
	All					Panel					Panel				
Variable	N	Mean	SD	Min.	Max.	N	Mean	SD	Min.	Max.	N	Mean	SD	Min.	Max.
Psychosocial work characteristics															
Workload	465	3.30	0.77	1.00	5.00	304	3.33	0.74	1.00	5.00	304	3.25	0.73	1.25	5.00
Role conflict	463	2.34	0.72	1.00	4.83	303	2.36	0.70	1.00	4.83	303	2.35	0.69	1.17	4.67
Role ambiguity	458	2.07	0.75	1.00	5.00	301	2.06	0.73	1.00	5.00	300	2.15	0.83	1.00	5.00
Mental demands[a]	459	3.63	----	1.50	5.00	302	3.63	----	1.50	4.88	300	3.50	----	1.50	5.00
Job insecurity	450	1.99	0.90	1.00	5.00	300	1.97	0.88	1.00	5.00	300	2.30	1.15	1.00	5.00
Employment insecurity	455	2.53	0.82	1.00	5.00	302	2.55	0.78	1.00	5.00	302	2.57	0.77	1.00	5.00
Job control	458	3.19	0.80	1.00	5.00	301	3.19	0.79	1.00	5.00	299	3.14	0.79	1.00	5.00
Social support (boss)	458	2.90	0.80	1.00	4.00	300	2.88	0.78	1.00	4.00	300	2.88	0.80	1.00	4.00
Social support (coworkers)	460	2.96	0.66	1.00	4.00	304	2.94	0.61	1.00	4.00	303	2.93	0.59	1.25	4.00
Unfairness (boss)	427	2.50	0.85	1.00	5.00	285	2.47	0.80	1.00	5.00	288	2.51	0.84	1.00	4.84
Unfairness (management)	410	2.73	0.84	1.00	5.00	277	2.70	0.80	1.00	5.00	283	2.78	0.83	1.00	5.00
Unfairness (wage)	437	3.97	0.94	1.00	5.00	291	4.00	0.88	1.00	5.00	299	3.99	0.97	1.00	5.00
Global job attitudes															
Job satisfaction	457	1.61	0.29	1.00	2.00	300	1.61	0.28	1.00	2.00	298	1.60	0.28	1.00	2.00
Global perceived job stress	460	1.40	0.93	0.00	3.00	300	1.40	0.90	0.00	3.00	299	1.40	0.92	0.00	3.00
Employee well-being															
Lack of well-being (GHQ-12-continuous) [a]	446	3.00	----	0.00	12.00	295	3.00	----	0.00	12.00	297	3.00	----	0.00	12.00
Clinically meaningful mental health symptoms (GHQ-12 score≥5)		Frequency		154	(34.5%)				107	(36.3%)				107	(36.3%)

[a] Because of the highly skewed distribution, the median is reported instead of the mean and SD.

3.1.2 Physical job demands

Table 3-2 summarizes the physical demands of the jobs included in this sample, derived from extensive observations and measurements. This table lists the total number of exertions required, regardless of the level of effort. It also reports the number and percentage of these exertions that were above the computed threshold for safe lifting (TLV). Table 3-2 further describes these jobs in terms of the effort location. That is, exertions were grouped by the horizontal reach distance of the activity (i.e., close to, intermediate, or far from the spine) and the vertical height at which the effort typically was applied (i.e., below mid-shin, between the mid-shin and knuckles, between the knuckles and shoulders, or above shoulder level).

The hourly, overall number of exertions required of these jobs varied tremendously. A few jobs involved only one exertion per hour, while others exceeded 500. The average was 130 per hour. Exertions were most likely to involve intermediate amounts of horizontal reaching, and efforts predominantly occurred in the knuckle-to-shoulder vertical range. By comparison, a small number of exertions were required either above the employee's shoulder or below the mid-shin.

In terms of the number of exertions above the computed TLV levels, the range was considerable. Some jobs had no exertions exceeding recommended limits, while others had 200 or more hourly efforts above the TLV. The average was 77 per hour. Not surprisingly, the intermediate reach and vertical height zones had the largest number of TLV-exceeding exertions. This was because these zones also involved the most exertions regardless of exertion level.

TABLE 3-2. Descriptive statistics for physical job exertions.

Region of exertion	Number of exertions (per hour)				Number of exertions above TLV (per hour)				Percent of exertions above TLV (per hour)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
All Regions	129.70	137.93	0	993	77.27	88.17	0	387	52.55	26.91	0	100
Horizontal Reach Regions[a]												
Close	31.46	31.92	0	170	6.02	7.81	0	34	20.42	23.06	0	100
Intermediate	69.28	75.50	0	653	41.03	45.66	0	197	52.80	27.97	0	100
Far	25.76	31.52	0	170	20.76	28.61	0	135	62.61	40.02	0	100
Vertical Height Regions												
Shoulder	5.91	12.55	0	94	5.03	10.01	0	62	43.63	48.82	0	100
Knuckle-to-Shoulder	96.23	115.17	0	552	54.23	82.09	0	381	43.43	29.31	0	100
Mid-shin-to-Knuckle	14.56	67.33	0	950	5.22	8.86	0	45	56.30	40.63	0	100
Floor-to-Mid-shin	5.78	15.11	0	117	5.76	15.11	0	117	44.36	49.74	0	100
Combined Height and Reach Regions												
Shoulder – Close	1.63	3.24	0	24	0.52	1.08	0	8	17.26	31.55	0	100
Shoulder – Intermediate	3.26	6.67	0	46	2.83	5.57	0	37	40.56	48.22	0	100
Shoulder – Far	1.04	2.91	0	24	1.04	2.91	0	24	25.25	43.50	0	100
Knuckle-to-Shoulder – Close	25.23	29.63	0	136	3.50	4.87	0	20	15.03	21.03	0	75
Knuckle-to-Shoulder – Intermediate	53.65	61.69	0	282	31.60	45.11	0	193	42.57	29.81	0	100
Knuckle-to-Shoulder – Far	21.31	28.87	0	135	17.71	29.02	0	135	55.47	43.19	0	100
Mid-shin-to-Knuckle – Close	3.14	11.74	0	160	1.11	3.32	0	50	17.72	32.63	0	100
Mid-shin-to-Knuckle – Intermediate	9.05	44.27	0	630	3.54	6.65	0	100	55.93	40.21	0	100
Mid-shin-to-Knuckle – Far	2.33	11.56	0	160	0.94	2.23	0	11	22.52	39.85	0	100
Floor-to-Mid-shin - Close	1.44	3.74	0	26	1.03	3.03	0	26	24.20	42.30	0	100
Floor-to-Mid-shin - Intermediate	3.06	7.01	0	50	3.06	7.01	0	50	44.61	49.77	0	100
Floor-Mid-shin - Far	1.07	3.46	0	26	1.07	3.46	0	26	29.41	45.62	0	100

[a] Horizontal Reach: Close = ≤30 cm from spine; Intermediate = 30-60 cm from spine; Far = 60+ cm from spine

3.2 Descriptive statistics for outcome variables

3.2.1 LMM LBP outcome

As described previously, the LMM measure provided the individual's age-adjusted probability of having normal back function. As shown in Table 3-3, participants were spread across the entire range of the probability of normal (pn) at both baseline and follow-up. Table 3-4 shows the number of participants who were categorized as LBP cases (i.e., probability of normal <0.50) at baseline and follow-up. At baseline, 121 (39.7%) of the 305 panel participants were categorized as cases. Of the 121 cases at baseline, 91 (75.2%) remained cases six months later while 30 (24.8%) improved enough to be categorized as non-cases. Of the 184 participants who were categorized as non-cases at baseline, 134 (72.8%) maintained their non-case status, but 50 (27.2%) became new cases. All together, 141 (46.2%) employees were categorized as cases at follow-up

Table 3-3. Descriptive statistics for Clinical LMM pn outcome

Probability of Normal (pn)	N	Mean	SD	Minimum	Maximum
All participants at baseline	467	0.57	0.27	0.01	1.00
Panel participants					
Baseline	305	0.55	0.27	0.01	1.00
Follow-up	305	0.50	0.27	0.01	0.98

Table 3-4. Prevalence of Clinical LMM pn cases.

		Baseline		
		LBP non-case	LBP case	Total
Follow-up	LBP non-case	134	30	164
		72.8%	24.8%	53.8%
	LBP case	50	91	141
		27.2%	75.2%	46.2%
Total		184	121	305

3.2.2 Self-report LBP symptoms

Figure 3-1 illustrates the distributions of two self-report LBP outcome measures. Both the neurogenic as well as the pain and disability symptom scales have a potential range of one though six. About half of the participants reported no symptoms on the neurogenic symptom scale. Among the panel participants, 139 (47.1%) reported no neurogenic symptoms at baseline and 159 (53.7%) at follow-up. The pain and disability scale shows a somewhat higher prevalence of symptoms. Among the panel participants, only 92 (32.6%) reported no pain or disability at baseline and 106 (36.8%) at follow-up.

3.2.3 Archived data

At the baseline, 5 (1.64%) of the 305 employees had records of back-related injuries on company OSHA 300 logs. At follow-up, 7 (2.30%) out of 305 had OSHA-recordable back related injuries. Because very few cases were recorded on these logs, no further analysis of these injuries was conducted.

3.3 Correlations between LMM pn and symptom outcomes

Table 3-5 shows the correlation coefficients for the LMM outcome (pn) and the self-report symptoms scale scores. Since the self-report scores are highly skewed, nonparametric correlation coefficients (Spearman's r) are reported. The correlations in Table 3-5 illustrate the negative relationships between the LMM and subjective self-report symptom scores (i.e., higher symptom scores are associated with lower LMM scores). Three of the six correlations were statistically significant at the 0.05 level; however, the correlations were weak.

Table 3-5. Spearman correlations between LMM pn and self-report symptom scores.

	Baseline (all)		Baseline (panel)		Follow-up (panel)	
	Neurogenic Symptoms	Pain & Disability	Neurogenic Symptoms	Pain & Disability	Neurogenic Symptoms	Pain & Disability
LMM pn	-0.069	-0.155	-0.116	-0.187	-0.103	-0.095
	p=0.149	p=0.001	p=0.047	p=0.002	p=0.077	p=0.108

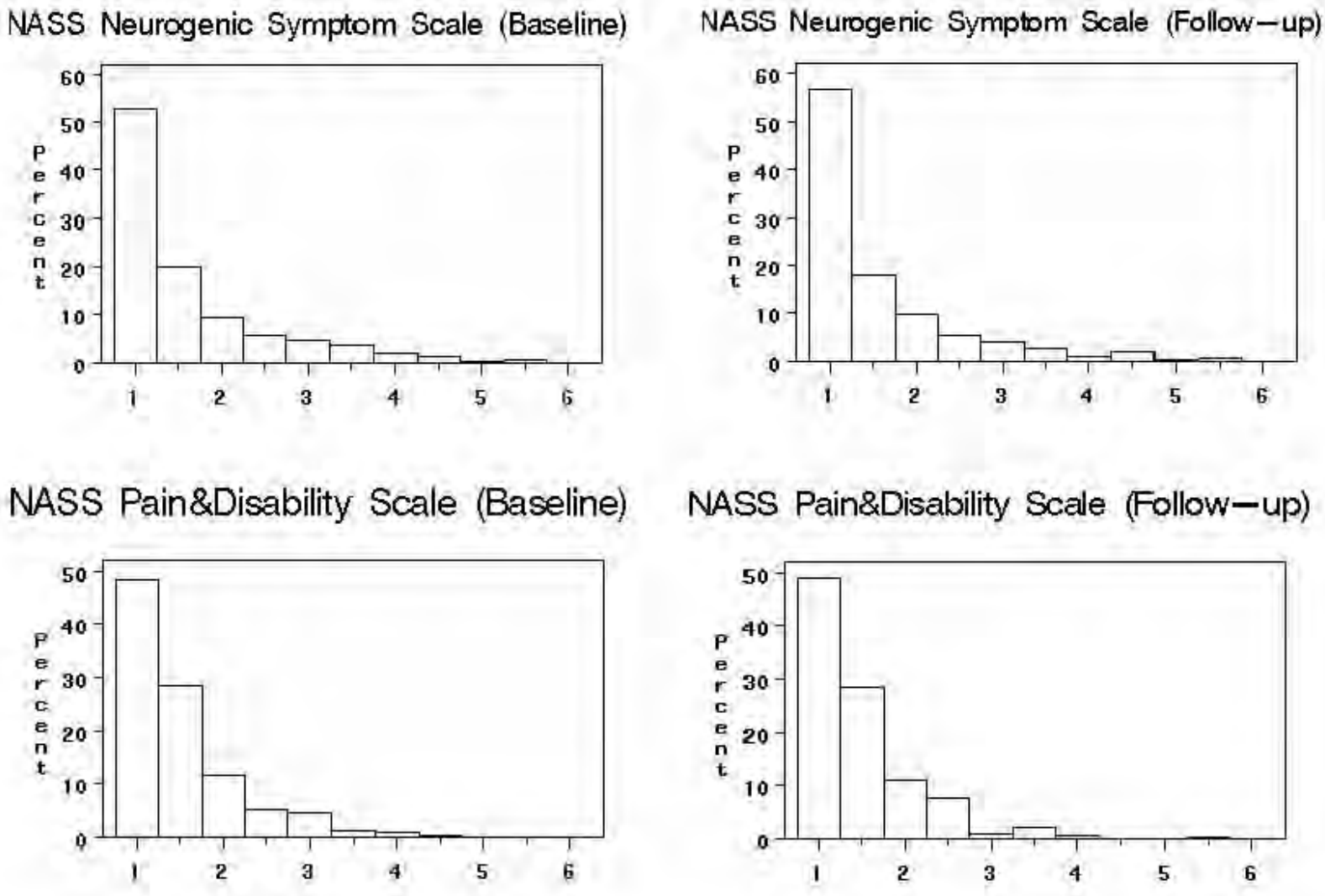


Figure 3-1. Distributions of self-report LBP symptoms scales.

3.4 Correlation between independent and outcome variables

3.4.1 Psychosocial work characteristics, global job attitudes, and employee well-being

In general, the zero-order correlations between psychosocial work characteristics, global job attitudes, and employee well-being variables and the LBP outcome variables were small or not significantly different from zero (correlation matrix is shown in Appendix A-3). LMM pn was not significantly correlated with any of the psychosocial work characteristics or global job attitudes at follow-up. Self-report symptom scales were significantly correlated with workload, role conflict, and global attitudes toward the job (i.e., job satisfaction, global perceived job stress), but the magnitude of the associations were small.

3.4.2 Physical job demands

The magnitude of association between physical job demands measures and LBP outcome measures was generally small and non-significant (see Appendix A-4). Baseline clinical LMM pn was correlated with more physical demands measures than follow-up LMM pn. The correlation coefficients were both negative and positive. Floor-to-mid-shin exertions are negatively correlated with LMM pn at baseline, indicating the more frequent exertions that were required in the jobs, the lower the LMM pn for employees in those jobs. In contrast, exertions in the knuckle-to-shoulder region far from the body were positively correlated with LMM pn. The more frequent the exertions were required in this region, the higher pn was for the employees in those jobs. The follow-up LMM pn was not correlated with physical demands measures, with one exception (i.e., total number of exertions in the knuckle-to–shoulder region, Spearman's r=0.115).

Self-report LBP symptom scores were not correlated with physical job demand measures with a few exceptions. The direction of the correlations was as expected. The more frequently exertions were required on the job, the higher the symptom scores for employees in those jobs.

4.0 PREDICTIVE MODEL RESULTS

Models were created to predict change in LBP outcome using the personal, psychosocial and physical job demands as well as interactions. Three outcome measures including: 1) pn, 2) pain and disability symptoms and 3) neurogenic symptoms were modeled using various statistical techniques. In all cases the models predicted the change in outcome between baseline and follow-up.

4.1 Approach 1: Linear regression models predicting change in LMM pn

The change in the LMM pn score from baseline to six-month follow-up was examined using two analytical approaches. The first set of analyses treated the LMM outcome as a continuum and used only a global indicator of physical job demands (i.e., percent of hourly exertions above TLV). In the second set of analyses, we focused on the amount of change in the LMM pn score that was likely to be clinically significant. In addition, a more detailed investigation was conducted on the large number of physical job demands measures in order to identify the most important types of physical demands. The variable selection process was assisted by CART, a nonparametric, local approach to select the most important variables in predicting a dichotomous outcome (discussed further in Section 4.2).

As discussed previously, the independent variables can be categorized into four domains: 1) personal characteristics (i.e., age, BMI, language, education, job tenure), 2) physical job demands, 3) psychosocial work characteristics (i.e., workload, mental demands, job control, social support), and 4) global job attitudes and well-being (i.e., job satisfaction, global perceived job stress, psychological well-being). These four types of independent variables were first examined separately and then simultaneously. In addition, interaction effects between 1) physical demands and psychosocial work characteristics, and 2) physical demands and job attitudes and well-being were explored.

4.1.1 Analysis of LMM pn change as a continuous variable

In this section, multivariate regression models are used to predict change in the LMM pn score. The change score was calculated as the follow-up score minus the baseline score. Thus, positive values of the change score indicate improvement in back functioning and negative values indicate worsening. Figure 4-1 shows the histogram for these change scores. The mean for the change scores is very close to 0, indicating that overall improvement in low back function was about equal to the amount of overall decrement in function.

All regression analyses predicting these change scores include the baseline pn score as a predictor. Underneath each table, the adjusted R^2 for the whole model and the adjusted ΔR^2 over and above the contribution of the baseline pn score are noted.

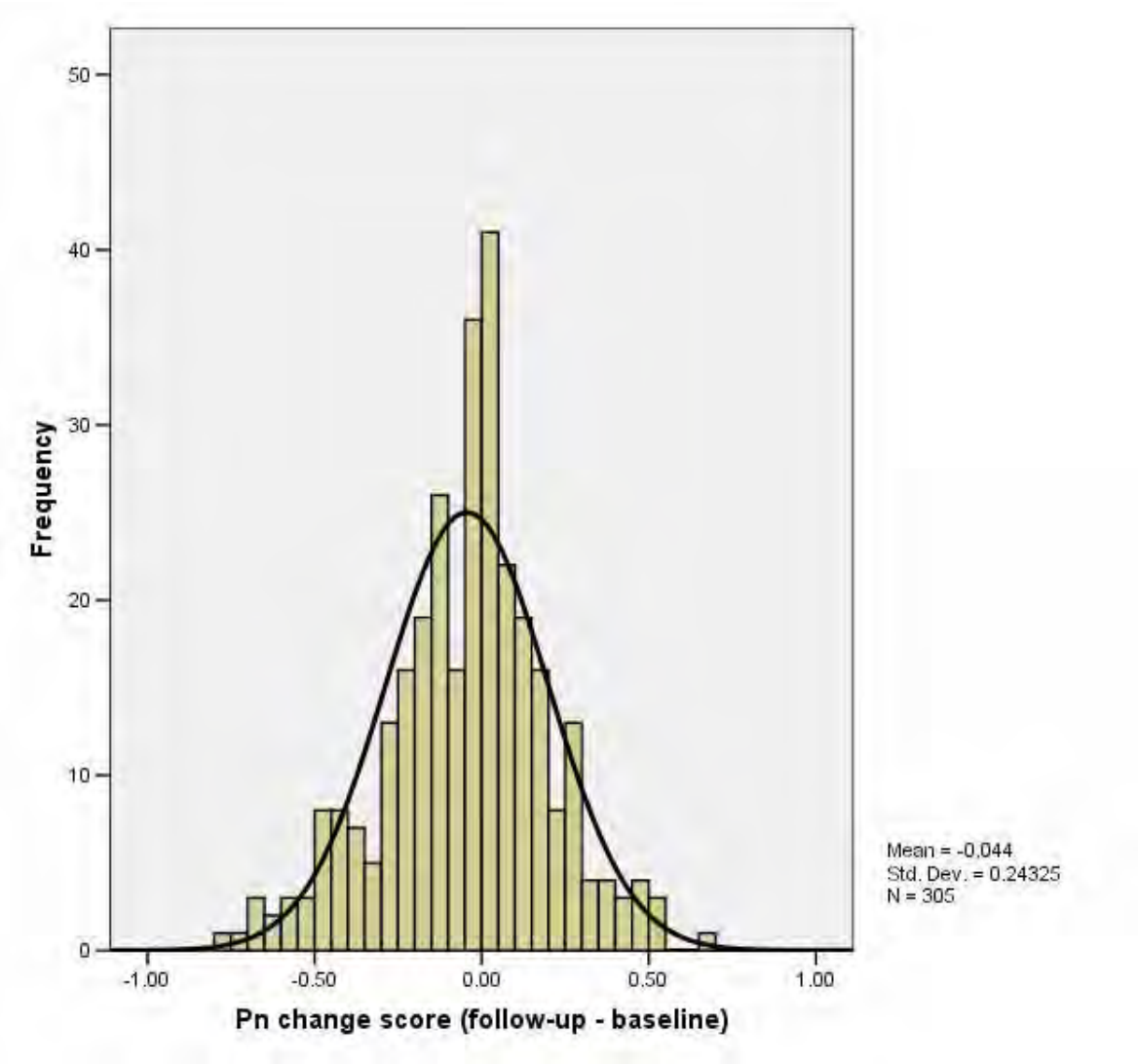


Figure 4-1. Distribution of change scores for LMM pn

4.1.2 Personal characteristics regression

Table 4-1 presents the results of a regression analysis including personal characteristics as predictor variables. After controlling for the initial level of pn, age, body mass index (BMI), and being a Spanish speaker were significantly associated with the change score. Being older, heavier, and Spanish-speaking were associated with having worsened back functioning at follow-up. *All subsequent regression models control for the effects of age, BMI, and being a Spanish speaker.*

Table 4-1. Regression model predicting change in LMM pn using personal characteristics as predictors.

Variable	DF	b	Beta	SE	t Value	p	95% CI for Beta	
Intercept	1	0.000	0.534	0.114	4.69	<.0001	0.310	0.758
LMM pn at baseline	1	-0.503	-0.452	0.050	-8.97	<.0001	-0.552	-0.353
Age	1	-0.236	-0.005	0.001	-3.92	0.000	-0.007	-0.002
BMI	1	-0.109	-0.005	0.003	-1.92	0.056	-0.010	0.000
Current smoker	1	-0.033	-0.017	0.029	-0.60	0.547	-0.073	0.039
Job tenure 1-5 years	1	0.052	0.026	0.034	0.75	0.455	-0.042	0.093
Job tenure 5+ years	1	0.023	0.012	0.040	0.30	0.766	-0.067	0.091
High school diploma	1	-0.049	-0.024	0.043	-0.56	0.574	-0.110	0.061
More than high school	1	-0.016	-0.008	0.044	-0.17	0.862	-0.095	0.079
Spanish speaker	1	-0.124	-0.114	0.052	-2.20	0.029	-0.216	-0.012

Adjusted R^2 = .237

4.1.3 Physical job demands regression

For these analyses, the overall level of physical demands are represented by three variables: the total number of exertions per hour (Number of Exertions), number of exertions per hour that were above TLV (Number above TLV), and percentage of exertions that were above TLV (% above TLV). Examining the distribution of each of these variables revealed natural cut-points for roughly trichotomizing the distribution of scores (See Figures 4-2, 4-3 and 4-4). The cut-points and frequencies are shown in Tables 4-2, 4-3 and 4-4. These variables were examined in the regression models, with the low demand group as the reference.

Table 4-2. Cut-points for physical job demands summary measures.

Physical demands measure		frequency	(%)
Total number of exertions per hour			
Low	<40 exertions per hour	94	31.2%
Medium	40 - 140 exertions per hour	116	38.5%
High	141 or more exertions per hour	91	30.2%
Number of exertions above TLV			
Low	<21 exertions per hour	120	39.9%
Medium	21 - 140 exertions per hour	119	39.5%
High	141 or more exertions per hour	62	20.6%
% above TLV			
Low	30.0%>	70	23.3%
Medium	30.0 - 69.1%	123	40.9%
High	69.1%<	108	35.9%

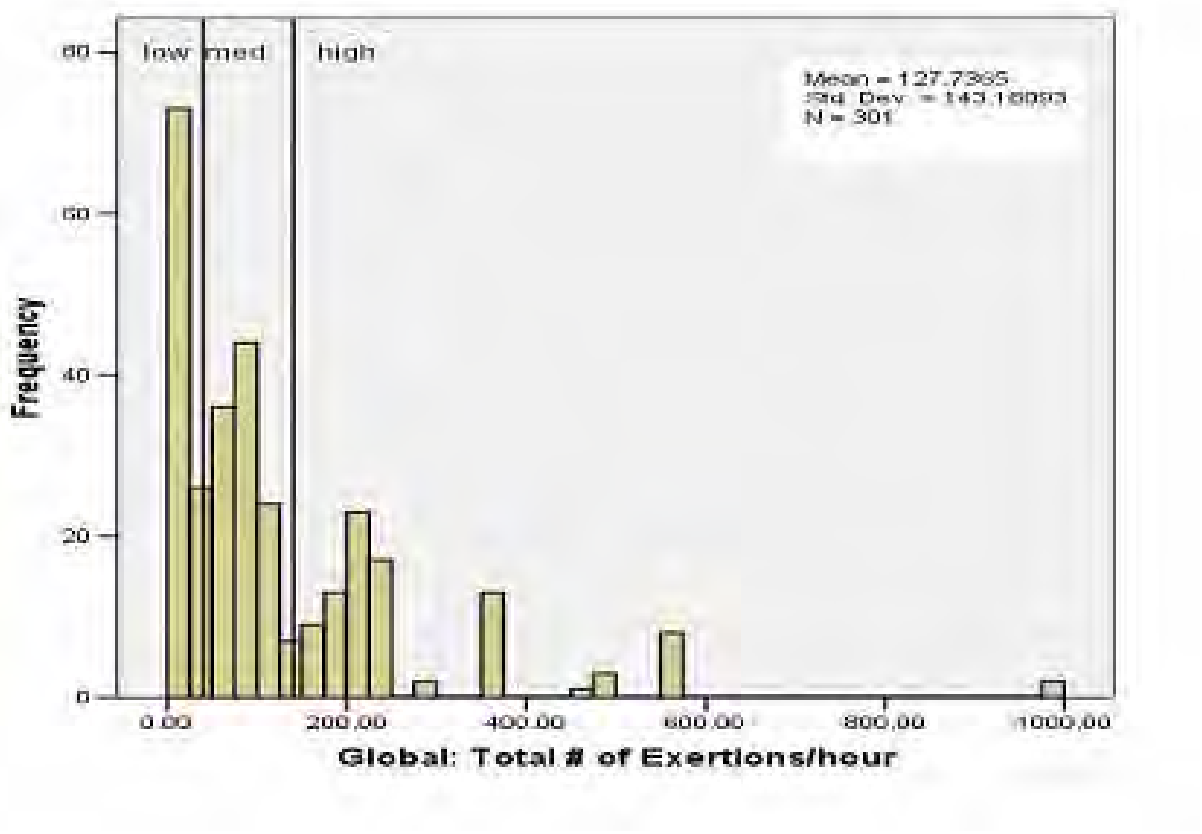


Figure 4-2. Distribution and cut-points for global: total number of exertion per hour

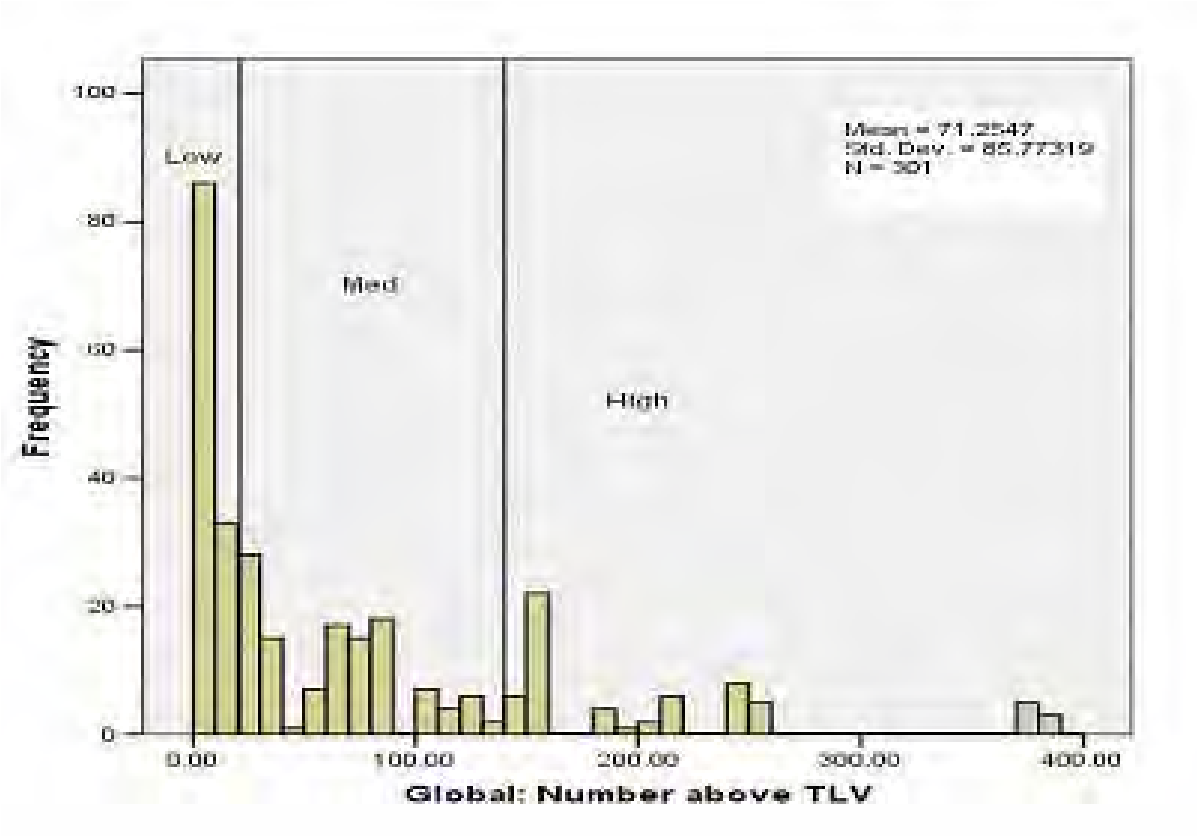


Figure 4-3. Distribution and cut-points for global:number of exertions above TLV

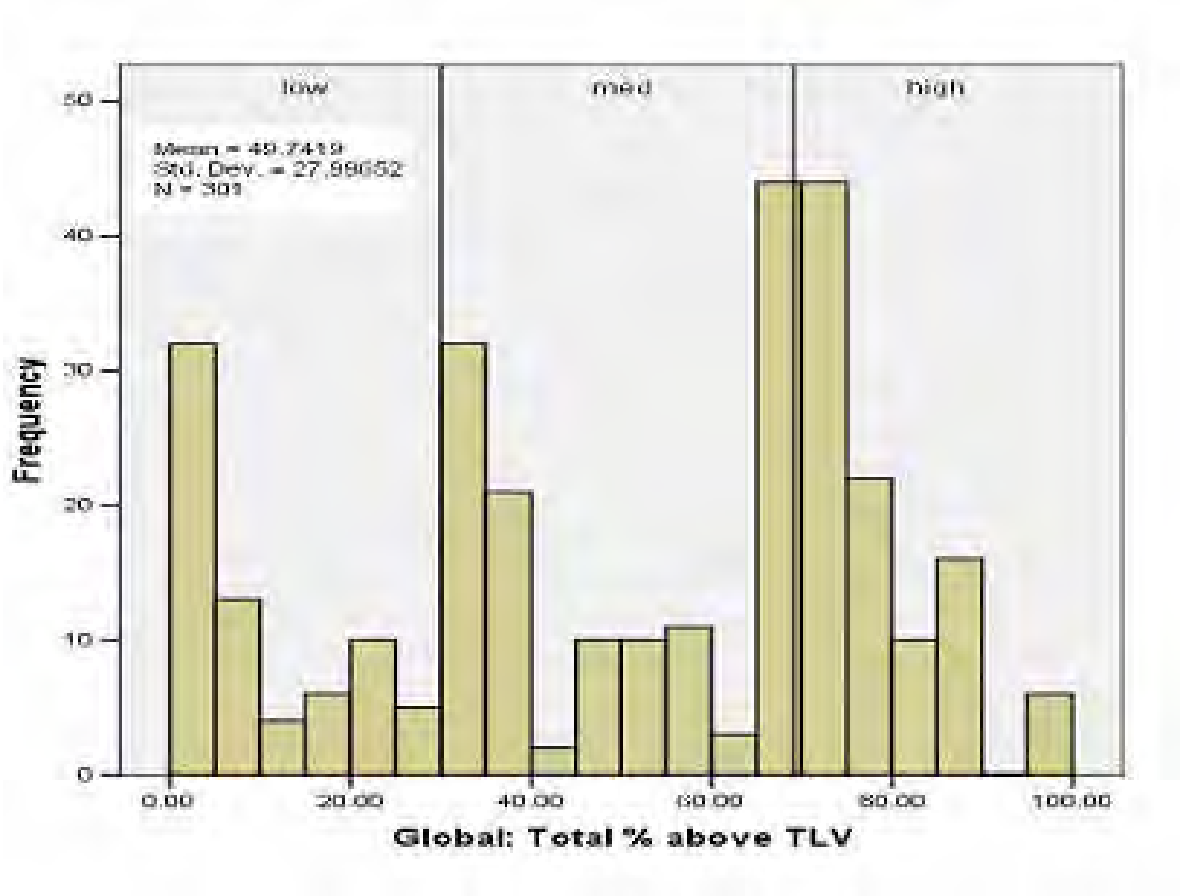


Figure 4-4. Distribution and cut-points for global: total percentage above TLV

Error!

Table 4-3 shows the result of a regression model predicting change of LMM pn using a physical job demands measure, the percent of hourly exertions above TLV. After controlling for the initial LMM pn and personal characteristics, the physical job demands added only marginally to the model. The medium and high physical job demand groups tended to have slightly lower change scores compared to the low physical job demand group. When similar models were run using the other physical job demands summary variables (i.e., number of hourly exertions and number of hourly exertions above TLV), the physical job demands variables were not significantly associated with the change in LMM pn at follow-up.

Table 4-3. Regression results with physical job demands as predictors of change in LMM pn

Variable	DF	b	Beta	SE	t Value	p	95% CI for Beta	
Intercept	1	0.276		0.088	3.125	.002	.102	.450
LMM pn at baseline	1	-0.463	-0.517	0.049	-9.467	.000	-.560	-.367
Personal characteristics								
Age	1	-0.005	-0.238	0.001	-4.459	.000	-.007	-.003
BMI	1	-0.007	-0.125	0.003	-2.328	.021	.001	.012
Spanish speaker	1	-0.087	-0.099	0.046	-1.903	.058	-.178	.003
Physical demands (%above TLV)[a]								
Medium demands	1	-0.054	-0.108	0.032	-1.659	.098	-.117	.010
High demands	1	-0.062	-0.122	0.034	-1.812	.071	-.130	.005

Adjusted R^2 = .253 ΔR^2=.065

[a]Low physical demands group (%aboveTLV<30.0%) as reference group

4.1.4 Psychosocial work characteristics regression

Based on the descriptive statistics and correlations presented earlier, the following psychosocial work characteristics were excluded from further analysis: job insecurity and employment insecurity because of low inter-item reliability; role conflict because of its high correlation with workload; and unfairness measures (unfairness of the supervisor, management, or wages) because of high correlations with social support from the supervisor. Role ambiguity was dichotomized (median split), and psychological well-being score was dichotomized between 4 and 5, with scores of 5 or greater indicating clinically significant levels of mental health problems.

Table 4-4 shows the result of regression analysis with psychosocial work characteristics as predictors of change in LMM pn. After controlling for baseline LMM pn and personal characteristics, none of the psychosocial work characteristics was associated with LMM pn change scores.

Table 4-4. Regression results with psychosocial work characteristics as predictors of change in LMM pn

Variable	DF	b	Beta	SE	t Value	p	95% CI for Beta	
Intercept	1	.214		.154	1.389	.166	-.090	.518
LMM pn at baseline	1	-.474	-.531	.050	-9.518	.000	-.572	-.376
Personal Characteristics								
Age	1	-.005	-.241	.001	-4.473	.000	-.007	-.003
BMI	1	.007	.128	.003	2.392	.017	.001	.012
Spanish speaker	1	-.094	-.106	.046	-2.049	.041	-.185	-.004
Psychosocial Work Characteristics								
Workload	1	-.004	-.010	.020	-.180	.857	-.042	.035
Role ambiguity	1	-.024	-.048	.028	-.836	.404	-.079	.032
Mental demands	1	.028	.068	.024	1.150	.251	-.020	.075
Job control	1	-.027	-.083	.018	-1.514	.131	-.061	.008
Social support (boss)	1	-.006	-.019	.018	-.326	.745	-.040	.029
Social support (coworkers)	1	.016	.040	.022	.734	.464	-.028	.060

Adjusted R^2 = .253 ΔR^2=.060

4.1.5 Global job attitudes and employee well-being

After controlling for personal characteristics, neither job satisfaction nor global perceived job stress was significantly associated with the change in LMM pn between baseline and follow-up. Table 4-5 shows the result of the regression analysis with employee mental health symptoms added as a predictor. Employees with higher symptom scores tended to have more of a decrement in low back function than did those with better mental health, but the effect is small and only marginally significant.

Table 4-5. Regression results with employee mental health symptoms as predictor of change in LMM pn

Variable	DF	b	SE	Beta	t Value	p	95% CI for Beta	
Intercept	1	.298	.087		3.412	.001	.126	.470
LMM pn at baseline	1	-.475	.049	-.536	-9.786	.000	-.571	-.379
Personal Characteristics								
Age	1	-.005	.001	-.238	-4.532	.000	-.007	-.003
BMI	1	.006	.003	.106	1.983	.048	.000	.011
Spanish speaker	1	-.107	.047	-.117	-2.284	.023	-.199	-.015
Employee mental health symptoms	1	-.009	.005	-.094	-1.819	.070	-.019	.001

Adjusted R^2 =. 261 ΔR^2=.067

4.1.6 Main effect model with personal characteristics, physical job demands, and psychosocial work characteristics

Table 4-6 shows the results of a regression model with personal characteristics, physical job demands, and psychosocial work characteristics. When these three categories of variables were

included in the model simultaneously, the personal characteristics (i.e., age, BMI, and Spanish) were associated with the change in LMM pn. The medium and high tertiles of physical demands were marginally associated with worse back functioning at 6-month follow-up than the low physical job demands group. None of the psychosocial work characteristics were significantly associated with the LMM pn change score.

Table 4-6. Regression results with personal, psychosocial work characteristics, and overall physical demands as predictors for change in LMM pn.

Variable	DF	b	S.E.	Beta	t	Pr > |t|	95%CI for b	
Intercept	1	.259	.157		1.653	.100	-.050	.567
LMM pn at baseline	1	-.479	.051	-.533	-9.453	.000	-.578	-.379
Personal characteristics								
Age	1	-.005	.001	-.252	-4.533	.000	-.008	-.003
BMI	1	.007	.003	.127	2.339	.020	.001	.012
Spanish speaker	1	-.081	.047	-.091	-1.730	.085	-.172	.011
Physical demands (% above TLV) [a]								
Medium demands	1	-.059	.033	-.118	-1.779	.076	-.124	.006
High demands	1	-.067	.035	-.130	-1.900	.058	-.136	.002
Psychosocial work characteristics								
workload	1	.004	.020	.011	.180	.858	-.036	.043
role ambiguity	1	-.023	.028	-.047	-.819	.414	-.079	.033
Mental demands	1	.023	.024	.057	.956	.340	-.024	.070
Job control	1	-.028	.018	-.088	-1.589	.113	-.063	.007
Social support (boss)	1	-.009	.018	-.030	-.515	.607	-.045	.026
Social support (coworkers)	1	.024	.023	.059	1.044	.297	-.021	.069

Adjusted R^2 = .257. ΔR^2=.063

[a] Low physical demands group (%aboveTLV<30.0%) as reference group

When models including personal characteristics, physical job demands, and either job satisfaction or global perceived job stress were run, neither job satisfaction nor global perceived stress were significant predictors (results not shown). When employee well-being was included, it was marginally significant. As shown in Table 4-7, employees with poorer mental health at baseline experienced slightly worsened low back function at follow-up.

Table 4-7. Regression results with personal, physical job demands, and psychological well being, as predictors for change in LMM pn

Variable	DF	b	Beta	SE	t Value	p	95% CI for Beta	
							.170	.533
Intercept	1	.352	.092		3.813	.000		
LMM pn at baseline	1	-.474	.049	-.533	-9.640	.000	-.571	-.377
Personal Characteristics								
Age	1	-.005	.001	-.256	-4.716	.000	-.008	-.003
BMI	1	.006	.003	.108	2.005	.046	.000	.011
Spanish speaker	1	-.089	.048	-.099	-1.874	.062	-.183	.005
Physical job demands[a]								
Medium	1	-.045	.032	-.092	-1.393	.165	-.109	.019
High	1	-.069	.035	-.135	-1.986	.048	-.137	-.001
Employee well-being	1	-.009	.005	-.097	-1.856	.065	-.019	.001

Adjusted R^2 = .264. ΔR^2=.069

[a] Low physical job demands group as reference group

4.1.7 Interaction models: Does the effect of psychosocial work characteristics differ at different levels of physical demands?

Regression models were used to assess potential interaction effects between physical job demands and psychosocial work characteristics. None of the interaction effects were statistically significant. However, when assessing the interactions between physical job demands and employee attitudes toward their jobs, the interaction between physical demands and job satisfaction was significantly associated with the change in probability of normal (Table 4-8). As illustrated in Figure 4-5, high job satisfaction was protective of low back function among employees in low physical demand jobs, slightly deleterious for employees in jobs with a moderate level of physical job demands, and unassociated with the change in probability of normal for those in jobs with the highest level of physical job demands.

Table 4-8. Regression results with individual, physical job demands, job satisfaction, and interactions as predictors for change in LMM pn.

Variable	df	b	S.E.	Beta	t	Pr > |t|	95%CI for b	
Intercept	1	.070	.166	---	.422	.673	-.191	.398
LMM pn at baseline	1	-.479	.049	-.534	-9.763	.000	-.575	-.382
Personal characteristics								
Age	1	-.005	.001	-.245	-4.551	.000	-.007	-.003
BMI	1	.007	.003	.132	2.459	.015	.001	.013
Spanish speaker	1	-.098	.047	-.109	-2.078	.039	-.257	-.005
Physical demands (% above TLV) [a]								
Medium demands	1	.336	.188	.675	1.785	.075	-.035	.707
High demands	1	.177	.196	.344	.906	.366	-.208	.563
Psychosocial Work characteristic								
Job satisfaction	1	.125	.089	.145	1.402	.162	-.051	.301
Interactions								
Job satisfaction* High physical job demands	1	-.148	.120	-.454	-1.238	.217	-.384	.087
Job satisfaction* Med physical job demands	1	-.236	.112	-.786	-2.098	.037	-.457	-.015

Adjusted R^2 = .271. ΔR^2=.074

[a] Low physical demands group (%aboveTLV<30.0%) as reference group

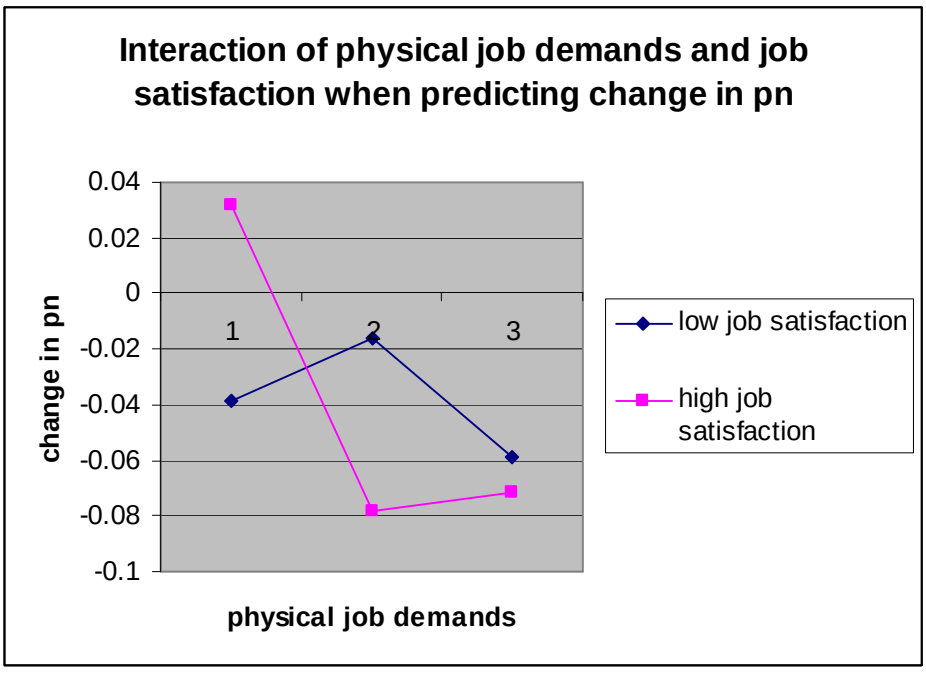


Figure 4-5. Interaction of physical job demands and job satisfaction when predicting change in pn

4.2 Approach 2: CART-assisted logistic regression analysis predicting change in LMM pn

4.2.1 Choosing the Outcome Variable

The second analytic approach focuses on prediction of a clinically meaningful decrement in low back functioning, rather than a continuous difference score. A dichotomous change variable was created with a 10% decrease in pn indicating such a decrement. Grotle et al (2004) indicated that a 10% change in functional status was needed in order to be clinically important. Using this criteria, 132 employees (43.3%) experienced a clinically meaningful decrement in low back functioning as measured by the LMM pn.

This dichotomous change variable is as independent of the baseline pn measure as possible (r=.22), thus obviating the need to include the baseline pn measure in the statistical models.

4.2.2 Problem of Variable Selection for Physical Demand Variables

There are a very large number of physical job demand variables. These correspond to 12 particular body regions (4 heights by 3 horizontal reaches) and 8 combined body regions (4 heights, 3 reaches, and overall), for a total of 20 body regions. For each region there are three variables measured: number of exertions per hour, number of exertions above a safe threshold, and percent of exertions above the threshold. Thus, there are 60 physical demand variables total. The 60 histograms and 1770 pairwise correlations were examined (not shown) for some guidance in determining important variables.

4.2.3 CART Methodology: Uses of Variable Selection and Honest Estimation of Misclassification Error Rate

Due to the large number of potential predictor variables, there was a need for statistical methodology for variable selection. It was desirable to have a nonparametric approach since there was no justification for strong model assumptions, and in order to facilitate fitting many models without a need to check assumptions. A powerful tool is the CART ("classification and regression trees") technology originally developed by Breiman et al (1984), and now commercially available from Salford Systems (Steinberg & Colla, 1997). The Breiman et al reference contains a full and detailed explanation of the methodology, theoretical justification, and examples from several fields, including medical. The other reference, from Salford Systems, is a user's manual for their user-friendly version of the software; it gives full details about the practical implementation of CART. In this report, only certain applications of CART (i.e., for classification of a dichotomous outcome variable) were used and will be explained as needed.

A few basic features of CART are described here. The CART method results in a "tree" by which a worker will be classified as "got worse" or "not worse". The classification is accomplished by dropping the worker down the nodes of a tree by answering yes-no questions as

to whether the worker has a variable value above or below a CART generated cutpoint. The method is highly computer-intensive. For example, to determine the best initial split of the data, CART considers all available predictor variables split at all possible values, computes a numerical "goodness-of-split" criterion for each split, and chooses the variable and split point with the best criterion value. The method is completely nonparametric, and local (i.e., based on the data being examined). Once the dataset is split, the data on the left and the right are treated separately in making further splitting decisions. CART was designed for the problem of automatically doing variable selection from a large number of predictor variables. The method solves the problem of "over-fitting" by first growing the largest possible tree, then "pruning" it back, and selecting the final tree based on a cross-validation procedure comparing all the possible sub-trees of the initial big tree. The final output produces honest estimates of misclassification error rates (by default, using 10-fold cross-validation).

4.2.4 Illustration of CART for Variable Selection using the Physical Job Demand Variables

Figure 4-6 is an example of a CART tree, which was built for the purpose of screening the 60 physical job demand variables. The CART tree shown is the optimal tree for predicting a 10% drop in LMM pn, given all 60 physical job demand variables as potential predictors and no other variables. (In fact the tree shown was not the optimal one, but was a smaller tree chosen for explanatory purposes. This tree has cross-validated relative cost within one SE of the optimal tree's cost and thus is a reasonable tree to consider.) There were 309 cases in the root node (Node 1), and the first node is split by answering the question "is the number of exertions per hour in the knuckle to shoulder area at an intermediate distance from the body <= 73?" Cases for which the answer is "yes" go left and are classified as Class=0 ("didn't get worse"); the others go right and are classified as "got worse." There are 237 cases in the left node and 72 in the right node (these are "children nodes" of the root node). These nodes are split on the variables *number of exertions above the TLV at a far distance from the body* and *number of exertions per hour in the floor to mid-shin area at a far distance from the body*, respectively. Further splits are made on the variables *the percent of exertions above the TLV in the knuckle to shoulder region, the number of exertions above the TLV in the knuckle to shoulder region, and the percent of exertions above the TLV at a far distance from the body*. Thus, out of the 60 physical job demand variables, CART produces a reduced set of six variables, which will be considered for final models.

In the illustration tree, the direction of the cut of the first node makes sense. Having more than 73 exertions per hour in the knuckle to shoulder area at an intermediate distance from the body results in the worker dropping into Node 6, which has a high preponderance of cases. These cases are further subdivided according to *number of exertions per hour in the floor to mid-shin area at a far distance from the body*, but now the very low values (<= .55) results in the worker going to Terminal Node 6 for final classification as a case who "got worse" whereas a worker with a higher number of exertions (> .55) was classified as a non-case. Although at first glance this is counterintuitive, there are several obvious explanations to consider. It is a small subset of the data being split at this point, so even with CART's pruning methodology this cut could be due to random noise. In general, the farther down the tree one goes, the less reliable the split.

Other potential explanations include confounding and possible cause-and-effect reversal. For example, if a person is doing a very low number of floor level exertions, it might be that a back problem has developed which is causing him to avoid those lifts. There are facilities in CART, which aid in interpretation of the trees which are built, both for checking for random noise and for masking of variables. However, at this stage of the data analysis, detailed model assessment was not done since CART was being used here just for variable screening; interpretability was not an issue. In some of the nodes, a split may be regarded as a fine-tuning of an earlier split. For example, Terminal Node 4 consists of those workers whose exertions per hour in the knuckle to shoulder area at an intermediate distance from the body were <=73, whose number of exertions above the TLV at a far distance from the body were <= 21.5, and whose percent of exertions above the TLV in the knuckle to shoulder region were > 36; those workers are classified as cases who “got worse”. In other words, for workers who appear at the first two cuts to have low physical job demands, they tend to develop a problem if the percent above TLV in the critical knuckle-shoulder body region is quite high.

A number of CART trees were run for various subsets of the 60 physical variables. The knuckle-shoulder variables appeared repeatedly as most important, especially in the intermediate reach zone; the floor to mid-shin variables were the next most important.

In an identical manner, CART trees were produced for predicting workers who had suffered a 10% or more decrement in pn given all 16 psychosocial variables (Table 3-1) and 15 personal characteristics (see Appendix 5). Then, the top five variables for each of the three categories of predictor variables were submitted for a final CART run to select the optimal ``combined'' model. Thus there were three preliminary variable screening steps---personal, physical, and psychosocial---and lastly, a step to build the final model with all three categories combined and equally represented.

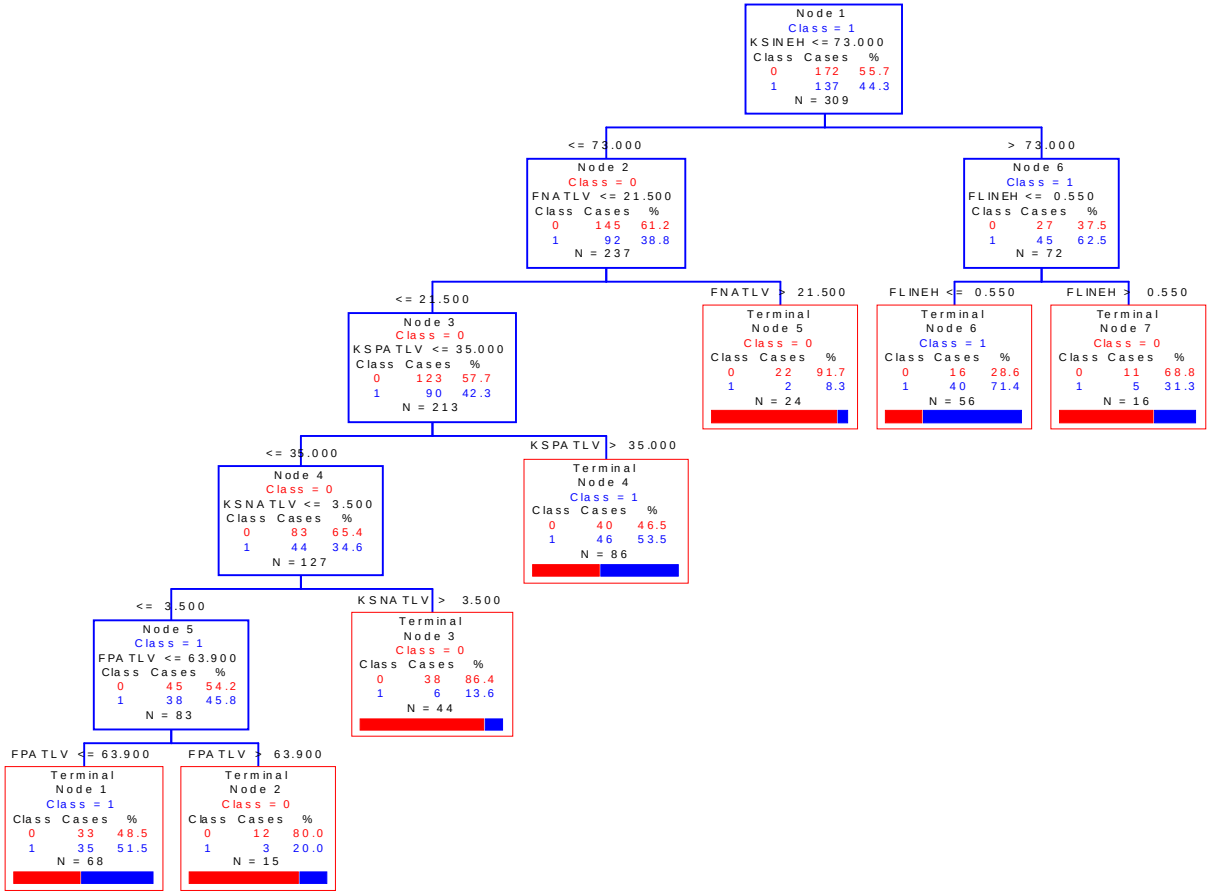


Figure 4-6. An example of a CART tree, built for screening 60 physical job demands variables. NOTE: KSINEH=knuckle-to-shoulder intermediate number of exertion, FNATLV= Far number of exertions above TLV, FLINEH= Floor- intermediate number of exertions, KSPATLV=knuckle to shoulder percentage of exertions above TLV, KSNATLV=knuckle-to-shoulder number above TLV, FPATLV= Far percentage of exertions above TLV

4.2.5 Results of CART for Variable Selection

The results of these studies are presented in Table 4-9. The table shows the variables selected by CART for each of the four model-building steps, and the estimates of error rates for both the learning (optimistic) and test sets (honest). The learning rates show how well the tree works on the data used to build the tree; in the following discussion, only the test set error rates are used.

The best model is the one with only the physical job demand variables; the error rates are 44% (for the cases) and 37% (for the non-cases). The model with just personal variables does better in terms of error rate for cases (31%) but much worse for non-cases (61%). It is interesting that the combined model does slightly worse uniformly than the model with just physical variables (error rates of 46% for cases and 43% for non-cases). The combined model was quite complex. Further work with CART trees, following the general approach outlined above, but with different CART parameters and different subsets of variables offered at the first three screening stages, did not result in simpler, clearer trees nor in better error rates.

Table 4-9. Summaries of CART models for classifying workers as having suffered a 10% or more decrement in LMM pn during the study period

Outcome Measure	Type of Predictor	Predictors Selected by CART	Learning		Test	
			Error Rate for "got worse" cases	Error Rate for non-cases	Error Rate for "got worse" cases	Error Rate for non-cases
Percentage change ((Pn2-Pn1)/Pn1)*100 If < -10% then 1 otherwise indicator=0	Psychosocial	Unfairness boss Work load Social Support Boss Job Insecurity Job Control Role Ambiguity Job Strain	12%	43%	51%	49%
	Personal	Age Height Weight	20%	50%	31%	61%
	Physical job demands (Allowing CART to Choose from 60 TLV variables)	Knuckle-to-Shoulder Intermediate Number of Exertions Far Number of Exertions above TLV Floor Intermediate Number of Exertions Intermediate Number of Exertion Overall Number of Exertions Intermediate Number of exertions above TLV Close Percentage above TLV Overall Number of Exertions above TLV Knuckle-to-Shoulder Far Percentage above TLV Knuckle-to-Shoulder Close Number of Exertions	23%	28%	44%	37%
	Combined Model Psychosocial, Personal and TLV	Knuckle-to-Shoulder Intermediate Number of Exertions Floor Number of Exertions above TLV Intermediate Number of Exertions Height Overall Number of Exertions Employment Insecurity Social Support Boss	28%	21%	46%	43%

4.2.6 Separate CART Models for Low, Medium, and High Physical Job Demand Groups

A more laborious and detailed procedure was needed to examine potential interaction among physical and psychosocial variables. A quite simple approach was taken to try to get around the obstacles, which arose repeatedly when all the data were modeled together. The data was split into quartiles of low to high physical demand. Three groups were formed on the basis of the physical job demands variable *the number of exertions per hour above the TLV in the knuckle to shoulder area at an intermediate distance from the body*: low quartile, middle 2nd and 3rd quartiles combined, and high quartile. This variable was one of those consistently found to be most important by CART. Three separate variable screening CART runs were carried out for each of the three data groupings. One model had personal variables only, one model had psychosocial variables only, and one model had the combination of personal and psychosocial variables. This was similar to the process described above where CART was used for variable selection on the dataset as a whole, except that this time the physical variables were not considered, since a physical variable had been used to split the data.

The original research hypothesis was that psychosocial variables would affect LBP in the low physical demand group but not in the high group. Thus, it would be expected that more psychosocial variables are important in the combined model for employees in the low physical job demands group than for those in the high physical job demands group. However, our current approach to studying interaction also allows for the possibility of more general types of interaction. In particular, different psychosocial variables might be important in the different groupings of physical job demands.

The results of the CART runs for the high, medium, and low physical demand group are shown in Tables 4-10, 4-11 and 4-12, respectively. Completely different psychosocial variables are selected for the low, medium, and high physical demand groups. In addition, more psychosocial variables are selected for the low physical job demands group than for the other two groups. However, the error rates for the combined models are slightly better in the high physical job demands group than in the low group. In order to confirm these results, CART diagnostics would need to be conducted in order to check the stability and interpretability of the results. An illustration of a diagnostic strategy is provided on the next page along with Figure 4-7 and Table 4-16.

Since the splitting of the data resulted in only about 75 observations in both the low and high physical demand groups, it was decided to also fit logistic regression models separately for the three groups. The predictors selected by CART for a particular group were the ones entered into the logistic regression model for that group. This was done to try to improve misclassification error rates with the parametric approach. For this purpose, the CART output was used to select cut-points at which to dichotomize the predictors, using the cut-point selected at the highest point where the variable appeared in the tree. Results of the high, medium, and low physical demand logistic regression models are shown in Tables 4-13, 4-14, 4-15, respectively.

For the low physical job demands group, the logistic model that included only the psychosocial work characteristics as predictors had the best combination of sensitivity (.80) and specificity (.73). For the high physical job demands group, the logistic model that included only the psychosocial work characteristics was also best, yielding a sensitivity of .74 and a specificity of .80. Thus, while resulting in qualitatively different fits to the data, both models had similar rates of overall misclassification.

The logistic model for the high physical job demands group has some counterintuitive results. The effects of unfair treatment from the boss and role conflict are not in the expected direction; more unfair treatment and more role conflict decrease the odds of being a "got worse" case. In order to investigate these effects, we returned to the CART model from which we identified the relevant psychosocial work characteristics. This CART tree is presented in Figure 4-7. It shows 4 terminal nodes. Means on several of the major study variables for the workers in each node are reported in Table 4-16.

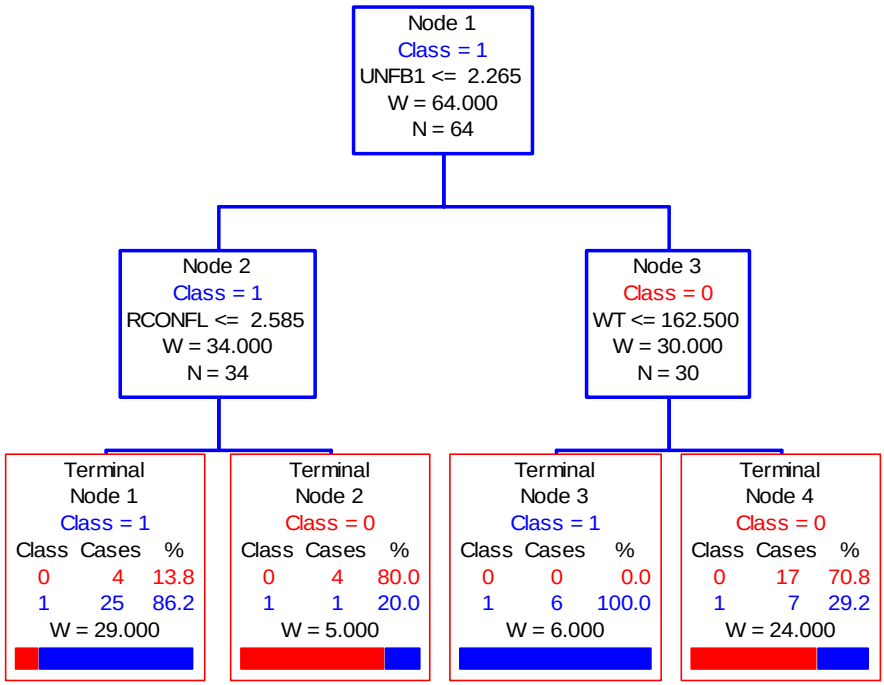


Figure 4-7. CART tree for investigating results of logistic regression for the high physical job demands group. NOTE: UNFB1 = unfairness boss baseline, RCONFL = role conflict baseline, WT = Weight

Table 4-10. CART results classifying workers as having suffered a 10% or more decrement in LMM pn during the study with a **high** physical job demand.

HIGH PHYSICAL JOB DEMANDS (n=64; 39 cases and 25 non-cases)

Type of Predictor	Predictors Selected by CART	Learning		Test	
		Error Rate for "got worse" cases	Error Rate for non-cases	Error Rate for "got worse" cases	Error Rate for non-cases
Psychosocial	Unfairness boss Role conflict Role ambiguity	18%	20%	33%	56%
Personal	Job Tenure job Weight	23%	28%	41%	48%
Personal + Psychosocial	Unfairness boss Role conflict Weight	23%	16%	28%	36%

Table 4-11. CART results classifying workers as having suffered a 10% or more decrement in LMM pn during the study with a **medium** physical job demand

MEDIUM PHYSICAL JOB DEMANDS (n=163; 57 cases and 106 non-cases)

Type of Predictor	Predictors Selected by CART	Learning		Test	
		Error Rate for "got worse" cases	Error Rate for non-cases	Error Rate for "got worse" cases	Error Rate for non-cases
Psychosocial	Job satisfaction Unfairness management	28%	36%	33%	40%
Personal	Age	9%	69%	19%	74%
Personal + Psychosocial	Job satisfaction Unfairness management Age	39%	23%	47%	38%

Table 4-12. CART results classifying workers as having suffered a 10% or more decrement in LMM pn during the study with a **low** physical job demand

LOW PHYSICAL JOB DEMANDS (n=82; 41 cases and 41 non-cases)

Type of Predictor	Predictors Selected by CART	Learning		Test	
		Error Rate for "got worse" cases	Error Rate for non-cases	Error Rate for "got worse" cases	Error Rate for non-cases
Psychosocial	Job control Role conflict Work load Job satisfaction Social support boss	12%	24%	29%	60%
Personal	Job Tenure MMH	46%	32%	44%	54%
Personal + Psychosocial	Job control Job Tenure MMH Social support boss Job satisfaction Workloads	12%	10%	36%	36%

Table 4-13. Results of logistic regression models based on CART results for the **high** physical job demand group. A personal, psychosocial and combined personal and psychosocial model was developed for the high physical demands.

PERSONAL

Variable	DF	Estimate	St. Error	Wald Chi-Square	P-Value Chi Square	Odds Ratio Point Est.	95% Confidence Interval		Sensitivity	Specificity
Intercept	1	1.9971	0.6942	8.277	0.004					
Job Tenure Job	1	-1.1137	0.5652	3.8824	0.0488	0.328	0.108	0.994	77	68
Weight	1	-1.2055	0.6554	3.3836	0.0658	0.300	0.083	1.080		

PSYCHOSOCIAL

Variable	DF	Estimate	St. Error	Wald Chi-Square	P-Value Chi Square	Odds Ratio Point Est.	95% Confidence Interval		Sensitivity	Specificity
Intercept	1	1.2972	0.4370	8.8119	0.0030					
Unfairness boss	1	-1.8267	0.6062	9.0802	0.0026	0.161	0.049	0.528	74	80
Role conflict	1	-0.9602	0.6865	1.9563	0.1619	0.383	0.100	1.470		
Role ambiguity	1	1.5951	0.8688	3.3705	0.0664	4.929	0.898	27.06		

PERSONAL AND PSYCHOSOCIAL

Variable	DF	Estimate	St. Error	Wald Chi-Square	P-Value Chi Square	Odds Ratio Point Est.	95% Confidence Interval		Sensitivity	Specificity
Intercept	1	2.1577	0.7051	9.3642	0.0022					
Unfairness boss	1	-1.5248	0.5769	6.9862	0.0082	0.218	0.070	0.674	77	64
Role conflict	1	-0.6752	0.6439	1.0996	0.2944	0.509	0.144	1.798		
Weight	1	-1.0795	0.6919	2.4344	0.1187	0.340	0.088	1.319		

Table 4-14. Results of logistic regression models based on CART results for the **medium** physical job demand group. A personal, psychosocial and combined personal and psychosocial model was developed for the medium physical demands.

PERSONAL

Variable	DF	Estimate	St. Error	Wald Chi-Square	P-Value Chi Square	Odds Ratio Point Est.	95% Confidence Interval		Sensitivity	Specificity
Intercept	1	-1.8867	0.4798	15.4607	0.0001					
Age	1	1.5475	0.5130	9.0997	0.0026	4.7	1.72	12.846	91	31

PSYCHOSOCIAL

Variable	DF	Estimate	St. Error	Wald Chi-Square	P-Value Chi Square	Odds Ratio Point Est.	95% Confidence Interval		Sensitivity	Specificity
Intercept	1	0.2714	0.3305	0.674	0.4117					
Job satisfaction	1	-1.5754	0.4142	14.4705	0.0001	0.207	0.092	0.466	68	65
Unfairness mngt.	1	1.0316	0.4077	6.4019	0.0014	2.806	1.262	6.238		

PERSONAL AND PSYCHOSOCIAL

Variable	DF	Estimate	St. Error	Wald Chi-Square	P-Value Chi Square	Odds Ratio Point Est.	95% Confidence Interval		Sensitivity	Specificity
Intercept	1	-1.081	0.5689	3.6112	0.0574					
Age	1	1.6512	0.5339	9.5658	0.0020	5.213	1.831	14.845	60	77
Job satisfaction	1	-1.6149	0.4337	13.8655	0.0002	0.199	0.085	0.465		
Unfairness mngt	1	1.1687	0.4302	7.3811	0.0066	3.218	1.385	7.477		

Table 4-15. Results of logistic regression models based on CART results for the **low** physical job demand group. A personal, psychosocial and combined personal and psychosocial model was developed for the **low** physical demands.

PERSONAL

Variable	DF	Estimate	St. Error	Wald Chi-Square	P-Value Chi Square	Odds Ratio Point Est.	95% Confidence Interval		Sensitivity	Specificity
Intercept	1	-0.3895	0.2826	1.8989	0.1682					
Job Tenure MMH	1	1.0825	0.4794	5.0976	0.0240	2.952	1.153	7.555	49	76

PSYCHOSOCIAL

Variable	DF	Estimate	St. Error	Wald Chi-Square	P-Value Chi Square	Odds Ratio Point Est.	95% Confidence Interval		Sensitivity	Specificity
Intercept	1	0.8414	0.6695	1.5794	0.2088					
Job control	1	-2.4013	1.0242	5.4969	0.0191	0.091	0.012	0.674	80	73
Role conflict	1	2.0072	0.7235	7.6961	0.0055	7.443	1.802	30.733		
Workload	1	-1.8996	0.7255	6.8568	0.0088	0.150	0.036	0.620		
Job satisfaction	1	1.4177	0.6061	5.4714	0.0193	4.128	1.258	13.539		
Social support boss	1	-0.9993	0.6391	2.4452	0.1179	0.368	0.105	1.288		

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Variable	DF	Estimate	St. Error	Wald Chi-Square	P-Value Chi Square	Odds Ratio Point Est.	95% Confidence Interval		Sensitivity	Specificity
Intercept	1	0.451	0.6919	0.4248	0.5146					
Job control	1	-1.9203	0.9641	3.9674	0.0464	0.147	0.022	0.970	78	61
Job tenure MMH	1	1.1932	0.5309	5.0521	0.0246	3.298	1.165	9.335		
Social support boss	1	-0.9319	0.6131	2.3103	0.1285	0.394	0.118	1.310		
Job satisfaction	1	1.336	0.5792	5.3212	0.0211	3.804	1.222	11.836		
Workload	1	-1.4929	0.7085	4.4408	0.0352	0.225	0.056	0.901		

Table 4-16. Means of potential confounders for the root node and terminal nodes of the CART tree in Figure 4-7

Variable	Node 1	T. Node 1 Case	T.Node 2 Non-case	T.Node 3 Case	T.Node 4 None-case
Age	32.4	34.0	27.8	32.3	31.4
Job tenure	32.8	34.9	23.4	29.3	33.2
Weight	196	193	196	150	211
Pn at baseline	.59	.63	.63	.59	.52
Unfairness boss	2.4	1.72	1.94	3.19	3.18
Unfair wage	4.19	3.91	4.4	4.1	4.5
Mental health symptoms	.26	.27	.50	.29	.25
Perceived job stress	1.5	1.26	2.18	1.66	1.67
Role conflict	2.19	1.82	2.94	2.64	2.37
Role ambiguity	2.15	1.95	1.70	2.88	2.29
Social support	3.00	3.09	3.10	2.96	2.90
Employment insecurity	2.60	2.41	2.60	2.22	2.91
Workload	3.36	3.02	4.05	3.67	3.54
Intermediate number of exertion above TLV	112	117	130	125	100
Knuckle-to-Shoulder Intermediate Number above TLV	106	113	125	117	92.3

The means in Table 4-16 can offer some insight into the characteristics of the clusters of workers. For the smaller nodes, Terminal Node 2 (n=5) is classed non-case even though the workers have higher physical job demands and worse psychosocial work characteristics than workers in the other nodes. However, the workers in this node are younger and this may serve as a protective factor. Terminal Node 3 (n=6) is an interesting cluster of workers with lower weights and high workload. For Terminal Nodes 1 and 4, physical job demands may be the main influence on low back function (even within the high physical job demand group). This table is presented only to illustrate how CART can be used to increase understanding of the logistic regression results.

4.3 Predicting change in symptom outcomes

4.3.1 Cross-tabulation of symptom outcomes

Two measures, adapted from the NASS, were used: (1) pain and disability score and (2) neurogenic symptoms score. In order to assess change in these measures, the continuous scores at baseline and follow-up were trichotomized at natural cut-points in the distributions. For the pain and disability score, the first category ("1") indicates that the worker had no symptoms. Category "2" indicates a symptom score between 1.1 and 1.9 and category "3" indicates a symptom score of 2 and above. For the neurogenic symptoms score, the first category ("1") also indicates that the worker had no symptoms. A "2" indicates a symptom score between 1.1 and 2.9 and a "3" indicates scores of 3 and above. The cut-points were created from the baseline distributions and were then applied to both the baseline and follow-up scores. For each measure, the baseline and follow-up trichotomized variables were cross-tabulated. Table 4-17 presents the cross-tabulations for the pain and disability trichotomized variables. The trichomized percentages do not appear to match Figure 3-1 due to the cut-points selected.

Table 4-17. Cross-tabulations of trichotomized pain and disability scores at baseline and follow-up

			Pain & Disability at Baseline Trichotomized			Total
			1.00	2.00	3.00	
Pain & Disability at Follow-up Trichotomized	1.00	Count	67	39	1	107
		Row Percentage	62.6%	36.4%	0.9%	100%
		Column Percentage	67.7%	27.3%	1.6%	35.3%
	2.00	Count	31	84	23	138
		Row Percentage	22.5%	60.9%	16.7%	100%
		Column Percentage	31.3%	58.7%	37.7%	45.5%
	3.00	Count	1	20	37	58
		Row Percentage	1.7%	34.5%	63.8%	100%
		Column Percentage	1.0%	14.0%	60.7%	19.1%
Total		Count	99	143	61	303

Based on this cross-tabulation, a change in pain and disability variable was created and coded as thus: 1=Stayed non-symptomatic, 2=got better, 3=Stayed mild/mod symptoms, 4=got worse, 5=stayed highly symptomatic. The same process was used for neurogenic symptoms. The frequencies for the change variables are presented in Table 4.18

Table 4-18. Cross-tabulations of trichotomized pain and disability, as well as neurogenic scores at baseline and follow-up

	Pain and Disability		Neurogenic Symptoms	
	Frequency	Percentage	Frequency	Percentage
Stayed non-symptomatic	67	22.1	40	13.2
Got better	63	20.8	106	35.1
Stayed Mild/Moderate	84	27.7	76	25.2
Got worse	52	17.2	52	17.2
Stayed highly symptomatic	37	12.2	28	9.3
Total	303	100	302	100

4.3.2 Bivariate relationships

To investigate the bivariate associations between each of these change variables and the major predictor variables, one-way ANOVAs were conducted using the change in symptoms variable as the grouping variable (see Appendices 6 and 7).

4.3.2.1 Biviariate relationship for pain and disability symptoms

The personal characteristic variables were not significantly associated with this outcome variable. The physical job demand variables were all associated with changes in pain and disability. The pattern of means indicated that the groups with the most exertions tended to be those who were chronically highly symptomatic, those who got worse, and those who remained non-symptomatic throughout the study. The former two groups may indicate a causal effect of physical job demands on the outcome. The latter group probably indicates a "healthy worker" group composed of those who are less vulnerable to problems associated with heavy exertion.

The psychosocial work characteristics almost all exhibited a similar pattern of association with change in pain and disability. Those employees who stayed non-symptomatic had the best psychosocial characteristics and those who stayed highly symptomatic had the worst. The other 3 groups (got better, got worse, mild/mod symptoms) fluctuated somewhere between these two anchors. Coworker support showed a slightly different pattern. Non-symptomatic employees reported the most support, but the highly symptomatic employees reported the next highest support. Those who got worse reported having the least coworker support. One explanation is that in the non-symptomatic group, coworker support was playing a preventive role. However, in the highly symptomatic group, coworker support is high because the focal employee needs (and asks for) the support in order to be able to accomplish his job.

The job attitude variables, job satisfaction and job stress, were also strongly associated with change in pain and disability. Employees who remained highly symptomatic reported the least satisfaction and the most stress, whereas those who stayed non-symptomatic or who got better reported the most satisfaction and the least stress. Figure 4-8 shows the cumulative distribution of job satisfaction for the 5 pain and disability groups. The curves for the highly symptomatic and non-symptomatic groups are the most different of the five.

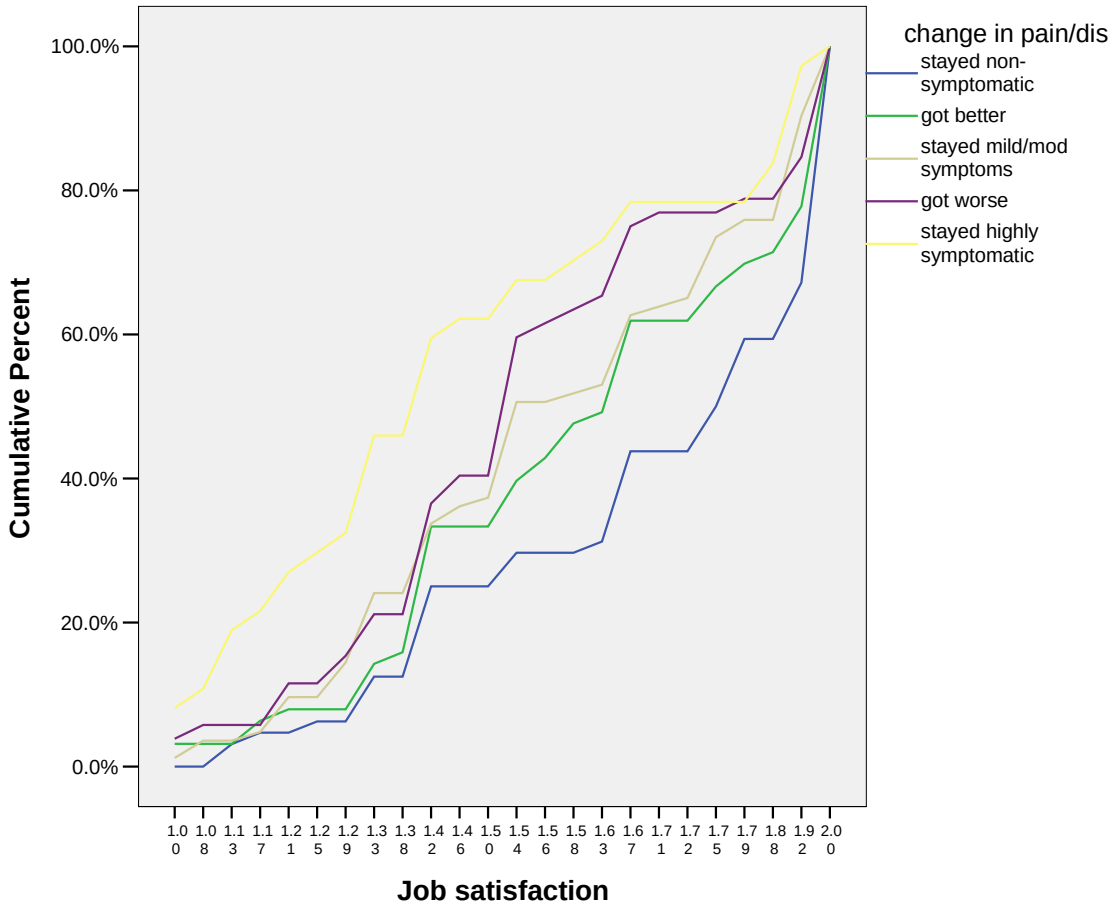

Figure 4-8. Cumulative distribution of job satisfaction as a function of pain and disability group.

4.3.2.2 Biviariate relationship for neurogenic symptoms

Age, BMI, and having taken the survey in Spanish were not significantly associated with change in neurogenic symptoms. The physical job demand variables were also not associated with this outcome variable. The overall pattern of means was as expected (e.g., those employees with the highest number of exertions became more symptomatic or stayed highly symptomatic), but the association was not statistically significant.

For the psychosocial work characteristics, coworker social support, supervisor social support, unfairness from the boss, management unfairness, workload, role conflict and role ambiguity were all significantly associated with change in neurogenic symptoms. In general, the patterns of means were as expected except for the "got better" group. For example, the "stayed non-symptomatic" group reported the least unfairness and the "stayed highly symptomatic" group reported the most unfairness. However, the "got better" group also reported high levels of unfairness.

This same anomalous pattern was present for the job attitude variables. The "got better" group had higher levels of job strain and lower levels of job satisfaction than expected. However, post-hoc comparisons indicate that only the non-symptomatic group significantly differed from the other groups (i.e., had significantly lower strain and higher satisfaction). For purposes of comparison, Figure 4-9 presents the cumulative distribution of job satisfaction for the 5 neurogenic symptom groups. Note that the "got better" group in neurogenic distribution displays a different relationship to the other groups compared to Figure 4-8.

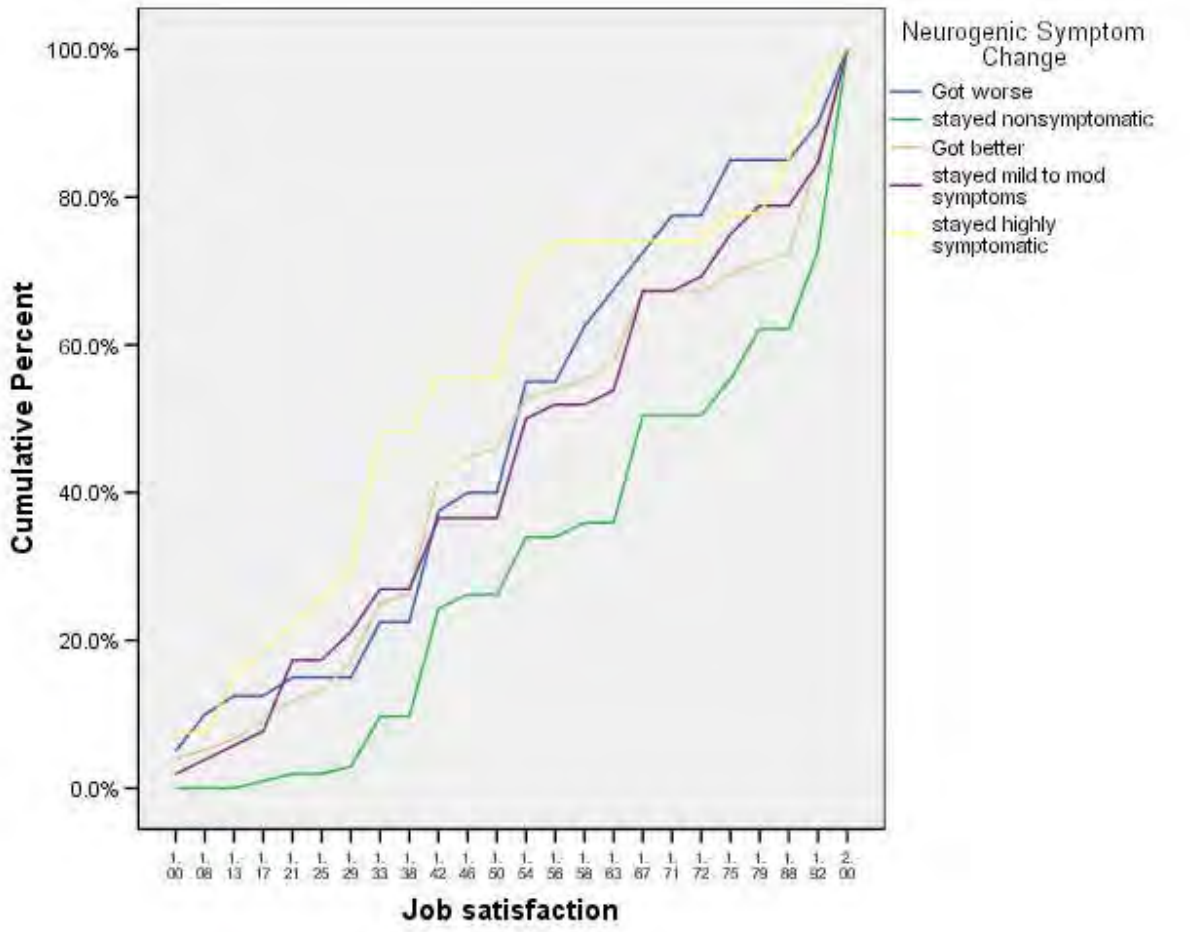

Figure 4-9. Cumulative distribution of job satisfaction as a function of neurogenic group.

4.3.3 Logist regression model for pain and disability symptoms

To assess multiple predictors simultaneously, stepwise multinomial logistic regression models were analyzed. In order to make the results more easily interpretable, the 5 category outcome variables were reduced to 3 categories. The "got better", "stayed mild/mod", and "got worse" groups were combined to form one symptom group. The "stayed non-symptomatic" group and

the “stayed highly symptomatic group” remained the same. Age and BMI were forced into the model first. At the next step,

The modeling procedure was as follows. Age and BMI were forced into the model first. At the next step, a forward selection procedure was used to choose from the physical job demand variables. An entry criterion of .10 was used. Once the physical job demand variables were chosen, they were forced into subsequent models (along with age and BMI). For the last step, a forward selection procedure was used to choose from the psychosocial work characteristics. Again, an entry criterion of .10 was used.

Table 4-19 summarizes the model building process for the pain and disability outcome and Table 4-20 presents the parameter estimates for the two logits of the final model. The Nagelkerke Pseudo R^2 for the final model is .275. The physical job demand variable selected through the stepwise analysis was the number of exertions above TLV in the knuckle-shoulder region. The results in Table 4-20 show that once the psychosocial work characteristics are allowed to enter the model, this physical job demand variable was no longer a significant predictor of change in symptoms. Role conflict significantly increases the odds of being in the mixed symptom group and the highly symptomatic group as compared to the non-symptomatic group. Unfairness significantly increases the odds of being in the mixed symptom group only.

Table 4-19. Summary logistic regression for change in pain and disability outcome.

Model	Action	Effects	Model Fitting Criteria		
			-2 Log Likelihood	Chi-Square (a)	Significance
0	Entered	Intercept Body Mass Index Age	431.667		
1	Entered	Knuckle-to-Shoulder Number of Exertions above TLV	425.346	6.321	0.042
2	Entered	Role Conflict	385.826	39.521	0.000
3	Entered	Unfairness Boss	373.387	12.439	0.002
4	Entered	Unfairness Management	367.216	6.170	0.046

Table 4-20. Parameter estimates for logistic regression for change in pain and disability outcome.

Change In Pain & Disability Tri-chotomized*	Variable	DF	Estimate	St Error	Wald Chi Square	P-Value Chi Square	Odds Ratio Point Est	95% Confidence Interval	
								Lower Bound	Upper Bound
Middle Symptoms Group	Intercept	1	-3.576	1.377	6.747	0.009			
	Body Mass Index	1	0.013	0.034	0.143	0.706	1.013	0.948	1.083
	Age	1	0.005	0.014	0.113	0.737	1.005	0.977	1.033
	Knuckle-to-Shoulder Number of Exertions above TLV	1	-0.001	0.002	0.080	0.778	0.999	0.995	1.003
	Role conflict	1	1.117	0.339	10.852	0.001	3.056	1.572	5.942
	Unfairness boss	1	1.055	0.332	10.060	0.002	2.871	1.496	5.508
	Unfairness management	1	-0.213	0.307	0.483	0.487	0.808	0.442	1.475
Stayed Highly Symptomatic	Intercept	1	-8.548	2.094	16.663	0.000			
	Body Mass Index	1	0.008	0.049	0.027	0.869	1.008	0.916	1.110
	Age	1	0.022	0.022	1.045	0.307	1.023	0.980	1.068
	Knuckle-to-Shoulder Number Exertions above TLV	1	0.004	0.003	1.875	0.171	1.004	0.998	1.009
	Role conflict	1	1.738	0.468	13.798	0.000	5.684	2.272	14.218
	Unfairness boss	1	0.393	0.430	0.835	0.361	1.482	0.637	3.446
	Unfairness management	1	0.652	0.425	2.355	0.125	1.919	0.835	4.411

* The reference category is: stayed non-symptomatic

4.3.4 Logist regression models for neurogenic symptoms

Table 4-21 summarizes the model building process for the neurogenic symptom outcome and Table 4-22 presents the parameter estimates for the two logits of the final model. The Nagelkerke Pseudo R^2 for the final model is .268. For the neurogenic symptoms, a slightly different physical job demand variable was selected: the number of exertions above TLV in the knuckle-shoulder region and intermediate moment arm. When the psychosocial work characteristics are allowed to enter the model, this physical job demand variable remains marginally significant. As seen in Table 4-22, intermediate knuckle-shoulder number of exertions above TLV significantly increases the odds of being in the highly symptomatic group compared to the non-symptomatic group. Similar to the results for change in pain and disability, role conflict greatly increases the odds of having neurogenic symptoms. Social support from the boss has a protective effect, reducing the odds of being symptomatic.

Table 4-21. Summary logistic regression for change in neurogenic symptom outcome.

			Model Fitting Criteria		
Model	Action	Effects	-2 Log Likelihood	Chi-Square (a)	Significance
0	Entered	Intercept Body Mass Index Age	463.278		
1	Entered	Intermediate knuckle-to-shoulder number of exertions above TLV	458.143	5.135	0.077
2	Entered	Role conflict	411.335	46.809	0.000
3	Entered	Social support boss	399.419	11.916	0.003

Table 4-22. Parameter estimates for logistic regression for change in neurogenic symptom outcome.

Change In Pain & Disability Tri-chotomized*	Variable	DF	Estimate	St Error	Wald Chi Square	P-Value Chi Square	Odds Ratio Point Est	95% Confidence Interval	
								Lower Bound	Upper Bound
Middle Symptoms Group	Intercept	1	-1.171	1.282	0.834	0.361			
	Body Mass Index	1	0.016	0.029	0.302	0.583	1.016	0.960	1.075
	Age	1	0.013	0.013	1.032	0.310	1.013	0.988	1.039
	Intermediate knuckle-to-shoulder number of exertions above TLV	1	0.002	0.003	0.377	0.539	1.002	0.995	1.009
	Role conflict	1	1.232	0.273	20.420	0.000	3.427	2.009	5.848
	Social support boss	1	-0.720	0.216	11.116	0.001	0.487	0.319	0.743
Stayed Highly Symptomatic	Intercept	1	-6.033	2.280	7.004	0.000			
	Body Mass Index	1	0.005	0.049	0.012	0.914	1.005	0.913	1.107
	Age	1	0.038	0.023	2.698	0.100	1.038	0.993	1.086
	Intermediate knuckle-to-shoulder number of exertions above TLV	1	0.013	0.005	6.860	0.009	1.013	1.003	1.022
	Role conflict	1	1.873	0.416	20.27	0.000	6.509	2.880	14.710
	Social support boss	1	-0.596	0.352	2.861	0.091	0.551	0.276	1.099

* The reference category is: stayed non-symptomatic

5. DISCUSSION

LBP is a function of personal, psychosocial and biomechanical risk factors. The literature review pointed out that many previous studies have used subjective single question self-reports of employee back pain to assess the problem. In order to overcome this methodological issue, three LBP outcome measures were used and all three have been previously validated. The literature review also indicated methodological discrepancies in both psychosocial and biomechanical assessment techniques. The psychosocial questionnaire in the current study was previously validated. In addition, the biomechanical exposure was objectively measured by a certified professional ergonomist using TLV guidelines developed by the ACGIH. Thus, both the surveillance as well as exposure assessment techniques used in this study have been scientifically developed. There were three specific aims in this study; 1) to identify the extent to which biomechanical demands and psychosocial characteristics of the job make independent contributions to the risk of LBP among employees performing manual material handling (MMH) activities, 2) to estimate the potential interaction effects of these two types of occupational exposures on LBP risk (i.e., the extent to which the biomechanical demands of the job influence the magnitude of the contribution of psychosocial job characteristics to overall risk of LBP), and 3) To compare the effects of biomechanical demands and psychosocial characteristics of the job on LBP risk using various indicators of morbidity.

The first specific aim to identify the extent to which biomechanical and psychosocial characteristics of the job made independent contributions to the risk of LBP was examined in several statistical analyses. The first analysis was a correlation analysis, which illustrates the association between the biomechanical or psychosocial characteristic and the LBP measure. Appendix 3 shows which individual psychosocial risk factors are associated with each of the three LBP outcomes. Both LBP symptom scores were significantly correlated with workload, role conflict, job satisfaction, and job strain and baseline and follow-up. The objective functional performance LMM pn indicator of low back impairment was not associated with any psychosocial measure at follow-up. Appendix 4 lists the individual physical demand factors that are associated with each of the three LBP outcomes. At baseline examining all of the data the symptom pain and disability questionnaire LBP measure was not associated with any of the physical demands and the neurogenic symptoms score was only associated with the percentage of exertions above the TLV in the far reach region in the knuckle to shoulder height region. On the other hand the objective functional performance LMM pn is associated with 17 of the 60 physical demand measures. This analysis indicates which biomechanical and psychosocial job characteristics made independent contributions to the risk of LBP as a function of the definition of LBP. The symptom measures were influenced more by the psychosocial factors whereas the objective functional performance LMM pn score was associated more with the biomechanical demands of the job.

Second, the linear regression analyses examined the specific aim of which biomechanical and psychosocial characteristics made independent contributions to the risk of LBP. The contributions of the personal characteristics were also examined to determine their independent contribution to risk of LBP. The linear regression model predicted change in LMM pn. The first

model used only personal factors and the results showed that age, BMI and Spanish speaker significantly contributed to the model. Therefore, these factors were put into all subsequent models. The personal characteristics were combined with biomechanical demands to determine the role of biomechanical demands (Table 4-3). In a second model the personal characteristics were combined with psychosocial work characteristics to determine the role of psychosocial factors (Table 4-4). Both biomechanical job demands and psychosocial work characteristics made independent contributions to predicting change in LMM pn.

Third, the CART analysis examined the specific aim of which biomechanical and psychosocial characteristics made independent contributions to the risk of LBP. CART models were constructed to predict two categories of change in low back functional performance. The workers low back function either "got worse" or "did not get worse". Separate models were constructed for the biomechanical and psychosocial variables. Table 4-9 shows CART selected 7 of the 15 psychosocial variables to predicted change in LMM pn function. The table also shows that CART selected 11 of the 60 physical job demand measures. The independent psychosocial model had a test set error rate of 51% and 49%. The independent physical demand model had a test set error rate of 44% and 37%. Since the test set error rates were marginal a different path was taken splitting the data into low, medium and high physical demands and constructing psychosocial models as a function of the physical demands level. The splitting of the data into low, medium and high physical demands leads to the examination of the second specific aim.

The second specific aim was to estimate the potential interaction effects of the biomechanical and psychosocial risk factors on LBP risk. The interaction was examined using several different statistical methods and each of the outcome measures was examined. First, the objective functional performance change in LMM pn outcome measure was evaluated using linear regression methods. In the regression model using the interaction of job satisfaction and physical demand for predicting change in LMM pn the interaction is clear. For high physical demand jobs both low and high job satisfaction groups have a decreased LMM pn. In the medium physical demand group both high and low job satisfaction groups had a decrement in LMM pn however, the high job satisfaction group had a greater decrement compared to the low job satisfaction group. In the low physical demand group the high job satisfaction group had an improved LMM pn where as the low job satisfaction group had a decrement in LMM pn. The complexity of the interaction between physical demands and job satisfaction found in this study may explain why the literature on the association between job satisfaction and LBP is so contradictory. In a literature Ferguson and Marras (1997) found 52% of studies had an association between job satisfaction and LBP however half of the studies in the review that examined job satisfaction did not even evaluate biomechanical risk factors. Neglecting to measure physical demands when evaluating job satisfaction may lead to erroneous conclusions. Davis and Heaney (2000) in another review article illustrated the change in association between low job satisfaction and LBP when biomechanical confounding factors were taken into account. Thus it is important to account for both job satisfaction and biomechanical exposure when determining the risk of LBP.

The specific aim of estimating the potential interaction of the biomechanical and psychosocial risk factors was further evaluated in the CART – assisted logistic regression. The CART-

assisted logistic regression analysis predicted a greater than 10% decrease in LMM pn outcome. The data was split into low, medium and high physical demands and a CART model was constructed for psychosocial, personal and a combination of personal and psychosocial risk factors. Since the psychosocial logistic regression models by physical demand group had the best sensitivity and specificity, the psychosocial model variable selection will be examined without personal characteristics. Table 5-1 illustrates the variation in psychosocial risk factors selected as predictors in the low, medium and high physical demand categories. It is noticeable that in the low physical demands category 5 risk factors were selected whereas in the medium and high physical demands 2 and 3 risk factors were selected, respectively. One of the original hypotheses was that psychosocial risk factors would play a more important role for developing LBP in the low physical demands category. The greater number of psychosocial risk factors selected in the low physical demands category supports this hypothesis. However, the hypothesis is not support by the medium risk group having fewer psychosocial factors selected than the high risk group. It is also noteworthy that none of the psychosocial risk factors appear in all three physical demands categories. This implies that different component of psychosocial demands contribute to the risk of developing LBP at different levels of physical demand. Furthermore, job satisfaction entered both the low and medium physical demand models and role conflict entered the low and high physical demand model. Thus role conflict has a greater impact at the extremes of the physical demand and job satisfaction has a greater role in low to moderate physical demand.

Table 5-1. Psychosocial risk factors select by CART as a function of physical demand group for predicting change in LMM pn.

	Physical Demand Categories		
Psychosocial Risk Factor	Low	Medium	High
Job Control	X		
Social Support Boss	X		
Job Satisfaction	X	X	
Workloads	X		
Unfairness Boss			X
Role Conflict	X		X
Unfairness Management		X	
Role Ambiguity			X

The model predicting trichotomized symptom outcome measures further examined the specific aim of evaluating the interaction of biomechanical and psychosocial risk factors on the risk of occupational LBP. Table 5-2 illustrates the physical and psychosocial risk factors selected for predicting change in symptom outcome during the study period. It is interesting to note that different physical demand measures were selected for each of the two symptom outcome measures but that both were statistically insignificant in the model once the psychosocial measures were added. The table also shows that only role conflict was selected for predicting, both pain and disability symptoms as well as neurogenic symptoms. In addition, social support boss, unfairness management and unfairness boss were in one of two models.

Table 5-2. Physical demands and psychosocial risk factors selected for predicting symptom outcome measures.

Risk Factor	Symptom Outcome Measures	
	Pain and Disability	Neurogenic
Physical		
Knuckle/Shoulder # above TLV	X	
Intermediate Knuckle/Shoulder # above TLV		X
Psychosocial		
Social Support Boss	X	
Role Conflict	X	X
Unfairness Management		X
Unfairness Boss		X

The lack of significance physical demand predictors in the symptom models once the psychosocial measures were entered emphasizes the importance of psychosocial measures in predicting symptom outcome measures. In the more objective functional performance outcome measure (LMM pn) both the physical demands and psychosocial factors were significant predictors. It is interesting to note that the psychosocial measure of role conflict entered both symptom measure models as well as the low and high physical demand change in LMM pn models. Thus, it would appear that role conflict was the most valuable psychosocial measure for predicting LBP across multiple outcome measures.

The final specific aim of the project was to compare the biomechanical and psychosocial characteristics of the job on LBP risk using various indicators of morbidity. This has been discussed to some extent with the previous two specific aims. Two subjective validated self-report questionnaires of pain symptoms and one objective functional performance measure (LMM pn) were used to assess LBP. Initially, OSHA 300 logs were also going to be used as an outcome measure however there was a lack of data from the participating companies to perform the analysis. The three outcome measures showed extremely different indications of LBP as evidenced by the correlations in Table 3.5. The low correlation indicated that the different outcome measures are tapping into different component of LBP and that pain symptoms do no necessarily indicate functional impairment. Liszka-Hackzell and Martin (2004) also found no relationship between pain symptoms and activity level in chronic LBP patients however these researchers did find a correlation in acute LBP patients. Gebhardt et al (2006) also reported no correlation between pain symptoms and straight leg raising function in the chronic LBP population. The lack of correlation between function and pain symptoms in the current study may suggest that the workers reporting LBP in our study have developed chronic LBP.

Further examining the effects of biomechanical and psychosocial characteristics of the job on the various outcome measures and relating to the literature. The correlation analysis showed that the symptom outcome measures were associated with a greater number of psychosocial risk factors compared to the biomechanical risk factors. The LMM pn outcome measure was correlated with a greater number of biomechanical risk factors compared to psychosocial risk factors. The greater number of psychosocial factors correlated with symptoms may be due to the mechanisms of pain perception. Winkelstein (2004) described that pain pathways and chemical mediators along the pain pathway. Brisby (2004) has suggested brain chemistry changes in chronic back

pain patients. It is hypothesized that occupational stress enhances the transmission of pain signals to the brain. This hypothesis is supported by the work of Greco et al (2004) who found that a brief stress-reduction program improved pain symptoms in patients experiencing pain from systemic lupus erythematosus.

The results of the analyses on personal factors, which was not listed as a specific aim, were found to be interesting. The most interesting results are for the BMI risk factor, which was a significant predictor of change in LMM pn but it was not a significant predictor of symptom outcomes. It is hypothesized that BMI has a greater influence on the objective physical impairment measures as compared to subjective symptom measures. There is an abundance of epidemiological literature exploring the association between BMI and LBP. Some researchers have found positive association between BMI and risk of LBP (Bener et al 2003, Liuke et al 2006) yet others have found no association between the two (Elders & Burdorf, 2004; Weiner et al., 2004). Crill and Hostler (2005) suggest that reduced back strength and flexibility due to increased level of BMI put EMS workers at greater risk of LBP. From this brief review of the literature it would appear that the association between obesity and LBP is dependent upon how obesity is quantified (continuous vs dichotomized) as well as the LBP surveillance measured used (symptoms, lost time, objective functional assessment).

Because our study focused on furniture distribution and not a variety of industries, the TLV data in this study is fairly homogeneous. These jobs tend to place workers at high risk for LBP based on the TLV indicators. Bureau of Labor Statistics (BLS, 2006) indicate that transportation and warehousing had the highest incidence rate of nonfatal occupational injuries and illnesses of all selected industries. The BLS statistics further suggest that furniture distribution may place a worker at high risk of injury. The nature of the furniture industry is that workers in management rise to the top by working their way up from the bottom of the company. Therefore, a worker currently in management may have previously worked on the floor performing heavy MMH. The earlier high physical exposure job may result in residual impaired functional performance. Cherniack et al. (2001) has found LMM pn was correlated with previous history of LBP. Thus it is hypothesized that some of the workers in low physical demand job had low LMM pn values at both baseline and follow-up because of prior exposure instead of current exposure levels. A prospective study with new hire workers at these types of facilities would assist in developing our understanding of impaired function and LBP.

6. LIMITATIONS

There are several limitations in this project. First, the biggest limitations of this were the economic forces of the time. The down turn in the economy during our study period lead to the closure of two facilities participating in the project. The closure eliminated follow-up data collection at one facility and greatly influence turnover at the second facility. The economic environment in general seemed to make facility managers less interested in cooperating in our research.

The second limitation is the high turnover rate. The high turnover rate is partly a function of the plant closure. However, in Facility 5, which was not influenced by plant closure there was a 44% turnover from those who participated at baseline. Thus, the overall turnover was high resulting low sample size at follow-up.

The third limitation was that all the distribution centers participating in the study were furniture distribution centers. Thus, the results are only applicable to furniture distribution centers. Using only one type of distribution center does increase the applicability of the results for that one specific industry.

The final limitation is that our personal factors did not included genetic information. Ala-Kokko (2002) has indicates that genetic polymorphisms may play a major roll in the development of lumbar disc degeneration a common cause of LBP. The lack of genetic information in our personal factors may limit our findings.

7. CONCLUSIONS

1. The three outcome measures (LMM pn, pain and disability, neurogenic) were very different indicators of LBP.
2. The symptom outcome measures were influenced more by psychosocial risk factors compared to biomechanical demand whereas LMM pn was influenced more by biomechanical risk factors compared to psychosocial factors.
3. The interaction between physical demands and psychosocial risk factors is complex and dependent upon which LBP outcome measure is used as well as the level of physical demand.

8. PUBLICATIONS

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2. Fujishiro K., Heaney CA. : [2006] Fairness at Work in the Job Stress Process: Mediating and Moderating Effects of Fairness. The 6th International Conference on Occupational Stress & Health, Miami Florida, March 2-4.

3. Fujishiro K: [2007] Reliability and Validity of Self-Reported Measures: A comparison between English and Spanish Versions. The 11th Biennial CDC/ATSDR Symposium on Statistical Methods, Atlanta, Georgia, April 17-18.

4. Fujishiro K, Heaney C: Justice at Work, Job Stress, and Employee Health. Submitted for review.

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Inclusion of gender and minority project study subjects

Principal Investigator/Program Director (Last, First, Middle): Marras, William, S.

Inclusion Enrollment Report

This report format should NOT be used for data collection from study participants.

Study Title: Biomechanical and Psychosocial Risk for Low Back Pain

Total Enrollment: 471 **Protocol Number:** 2002H0209

Grant Number: R01 OH03914-03

PART A. TOTAL ENROLLMENT REPORT: Number of Subjects Enrolled to Date (Cumulative) by Ethnicity and Race

Ethnic Category	Sex/Gender			
	Females	Males	Unknown or Not Reported	Total
Hispanic or Latino	5	60		65 **
Not Hispanic or Latino	21	352		373
Unknown (individuals not reporting ethnicity)	0	33		33
Ethnic Category: Total of All Subjects*	26	445	-0	471 *
Racial Categories				
American Indian/Alaska Native	0	6		6
Asian	1	7		8
Native Hawaiian or Other Pacific Islander	0	0		0
Black or African American	3	102		105
White	17	237		254
More Than One Race	0	0		0
Unknown or Not Reported	5	93		33
Racial Categories: Total of All Subjects*	26	445		471 *

PART B. HISPANIC ENROLLMENT REPORT: Number of Hispanics or Latinos Enrolled to Date (Cumulative)

Racial Categories	Females	Males	Unknown or Not Reported	Total
American Indian or Alaska Native	0	0		
Asian	0	0		
Native Hawaiian or Other Pacific Islander	0	0		
Black or African American	0	0		
White	0	0		
More Than One Race	0	0		
Unknown or Not Reported	5	60		
Racial Categories: Total of Hispanics or Latinos**	5	60	0	65 **

* These totals must agree.
** These totals must agree.

APPENDICES

APPENDIX A-1

Response rate by facility

A-1 Response rate by facility

Baseline						Follow-up					
1		**English**		**Spanish**			**English**		**Spanish**	
	6/14,21/2004	46		1		11/22/2004	24		0	
Columbus		En-self	En-int	Sp-self	Sp-int		En-self	En-int	Sp-self	Sp-int
		45	1	1	0		23	1	0	0
	Survey total =	47				**Survey total =**	24	**Phone int. =**	1	
	LMM total =	45				**LMM total =**	25	1 came into the lab		
	Part. total =	47	Survey only = 2			**Total =**	25	Total w/ ph. =	26	

2		**English**		**Spanish**			**English**		**Spanish**	
	8/2/2004	34		19			0		0	
Greensboro		En-self	En-int	Sp-self	Sp-int		En-self	En-int	Sp-self	Sp-int
		33	1	12	7		0	0	0	0
	Survey total =	53				**Survey total =**	0			
	LMM total =	53				**LMM total =**	0			
	Part. total =	53				**Total =**	0			

3		**English**		**Spanish**			**English**		**Spanish**	
	8/23/2004	80		5		2/21/2005	60		3	
Atlanta		En-self	En-int	Sp-self	Sp-int		En-self	En-int	Sp-self	Sp-int
		77	3	4	1		59	1	3	0
	Survey total =	85				**Survey total =**	63	**Phone int. =**	3	
	LMM total =	85				**LMM total =**	63			
	Part. total =	85				**Total =**	63	Total w/ ph. =	66	

4		**English**		**Spanish**			**English**		**Spanish**	
	9/13/2004	40		32		3/14/2005	28		24	
Chicago		En-self	En-int	Sp-self	Sp-int		En-self	En-int	Sp-self	Sp-int
		40	0	29	3		28	0	21	3
	Survey total =	72	Survey only =		1	**Survey total =**	52	**Phone int. =**	1	
	LMM total =	72	LMM only =		1	**LMM total =**	52			
	Part. total =	73				**Total =**	52	Total w/ ph. =	53	

5		**English**		**Spanish**			**English**		**Spanish**	
	1/17, 24/2005	25		0		8/15/2005	14		0	
Arhaus		En-self	En-int	Sp-self	Sp-int		En-self	En-int	Sp-self	Sp-int
		22	3	0	0		12	2	0	0
	Survey total =	25				**Survey total =**	14			
	LMM total =	25				**LMM total =**	14			
	Part. total =	25				**Total =**	14			

Baseline						Follow-up					
6		English		Spanish			English		Spanish		
	2/28/2005	75		0		10/30/2005	57		0		
Big Sandy		En-self	En-int	Sp-self	Sp-int		En-self	En-int	Sp-self	Sp-int	
		74	1	0	0		57	0	0	0	
	Survey total =	75				**Survey total =**	57				
	LMM total =	75				**LMM total =**	57				
	Part. total =	75				**Total =**	57				

7		English		Spanish			English		Spanish		
	8/4-5/2005	21		1		2/8, 2/16/2006	19		1		
Columbus		En-self	En-int	Sp-self	Sp-int		En-self	En-int	Sp-self	Sp-int	
		21	0	1	0		19	0	1	0	
	Survey total =	22				**Survey total =**	20				
	LMM total =	22				**LMM total =**	19				
	Part. total =	22				**Total =**	20				

8		English		Spanish			English		Spanish		
	10/30-11/2/2005	61		4		5/1-5/3/2006	57		4		
Office Max		En-self	En-int	Sp-self	Sp-int		En-self	En-int	Sp-self	Sp-int	
		61	0	4	0		56	1	4	0	
	Survey total =	65				**Survey total =**	61				
	LMM total =	64				**LMM total =**	58				
	Part. total =	65				**Total =**	61				

9		English		Spanish			English		Spanish		
	12/8-12/9/2006	26		0		6/7-6/8/2006					
Cincinnati		En-self	En-int	Sp-self	Sp-int		En-self	En-int	Sp-self	Sp-int	
		26	0	0	0		23	0	0	0	
	Survey total =	26				**Survey total =**	23				
	LMM total =	26				**LMM total =**	23				
	Part. total =	26				**Total =**	23				

Survey total = 470
LMM total = 467
 # in database = 471

LMM only = 1
Survey only = 3

English self = 399
English interv. = 9
Spanish self = 51
Spanish interv. = 11

Survey total = 314
LMM total = 311

LMM only = 1
Phone interview = 5

Survey only = 4

English self = 277
English interv. = 5
Spanish self = 29
Spanish interv. = 3

Baseline	Drop-out rate		Reason no FU		
	BL-FU	BL-FU/BL	Left	Not available	Still at company but Unknown
1 Rhodes Columbus	**22**	0.468085	16	7	
2 Rhodes Greensboro	**53**	1	**CLOSED**		
3 Rhodes Atlanta	**22**	0.258824	10	9	3
4 Rhodes Chicago	**21**	0.287671	16	4	
5 Arhaus	**11**	0.44	6	4	1

Baseline		Drop-out rate		Reason no FU		
6	Big Sandy	**18**	0.24	13	2	3
7	OMF Columbus	**2**	0.090909	2	0	0
8	Office Max	**4**	0.061539	3	1	0
9	OMF Cincinnati	**3**	0.115385			

 # drop-out for 8 facilities = 100
Av. drop-out rate for 8 = 0.245302

Reason No FU: sum		
Left	NA	UK
66	**27**	**7**

APPENDIX A-2

Questionnaire

For OSU office use only

Low Back Pain Survey

The Ohio State University
College of Engineering and School of Public Health

This survey is part of a study being conducted by the Ohio State University College of Engineering and School of Public Health in order to better understand low back pain among workers like yourself. This survey asks about your health, your job, and your feelings about your job.

Your participation is voluntary and your responses will be kept completely confidential. Your responses will not be seen by anyone except research staff at the Ohio State University. Only overall results of the survey will be reported publicly. This means that no one at your company will know how you responded to these questions. Your answers to the questions in the survey will not have any effect on your job or your relationship with your company.

INSTRUCTIONS:

1. Do not place your name anywhere on your survey.
2. There are no right or wrong answers to these questions. Your honest opinion is what matters, so please be as frank as possible in your answers.
3. Please be careful not to skip pages when you turn pages.
4. Please try to answer every question. Some questions may look like others, but each one is different and important.
5. While we would very much like you to answer all of the questions, it is fine to leave a question blank if you do not feel comfortable answering it.

Your Work Schedule

1. **Please think back to a week ago today. Starting that day, fill in the chart below. Please write down the day of the week, what time you started and ended work at this company. (circle AM or PM)**

Day of the week	Starting time		Ending time		
Example Mon	7 : 30	(AM) PM	5 : 30	AM (PM)	❑ I did not work that day
Day of the week	**Starting time**		**Ending time**		
	:	AM PM	:	AM PM	❑ I did not work that day
	:	AM PM	:	AM PM	❑ I did not work that day
	:	AM PM	:	AM PM	❑ I did not work that day
	:	AM PM	:	AM PM	❑ I did not work that day
	:	AM PM	:	AM PM	❑ I did not work that day
	:	AM PM	:	AM PM	❑ I did not work that day
	:	AM PM	:	AM PM	❑ I did not work that day

2. **Look over the hours that you listed above. To what extent does this look like a typical work week for you? Please check one.**

   ❑ Not at all typical

   ❑ Somewhat typical

   ❑ Very typical

3. **In <u>an average week</u>, how many hours do you work in your current job at this company?**

   _____hours

About Your Job

Please mark <u>one box</u> for each question.

1. **How often do you have too many different things to do at work?**

   - ❑ Never
   - ❑ Rarely
   - ❑ Sometimes
   - ❑ Often
   - ❑ Almost all the time

2. **How often does your job require you to work very fast?**

   - ❑ Never
   - ❑ Rarely
   - ❑ Sometimes
   - ❑ Often
   - ❑ Almost all the time

3. **How often do you receive conflicting requests from two or more people?**

   - ❑ Never
   - ❑ Rarely
   - ❑ Sometimes
   - ❑ Often
   - ❑ Almost all the time

4. **How often does your job require you to work very hard?**

   - ❑ Never
   - ❑ Rarely
   - ❑ Sometimes
   - ❑ Often
   - ❑ Almost all the time

5. **How often do you feel pressure to do things that you think may not be best?**

   - ❑ Never
   - ❑ Rarely
   - ❑ Sometimes
   - ❑ Often
   - ❑ Almost all the time

6. **How often do you do things that are apt to be accepted by one person and not accepted by others?**

   - ❑ Never
   - ❑ Rarely
   - ❑ Sometimes
   - ❑ Often
   - ❑ Almost all the time

7. **How often is there a great deal to be done?**

   - ❑ Never
   - ❑ Rarely
   - ❑ Sometimes
   - ❑ Often
   - ❑ Almost all the time

8. **How often do you have to do things on the job that are against your better judgment?**

   - ❑ Never
   - ❑ Rarely
   - ❑ Sometimes
   - ❑ Often
   - ❑ Almost all the time

9. **How often does your job leave you with little time to get things done?**

   - ❑ Never
   - ❑ Rarely
   - ❑ Sometimes
   - ❑ Often
   - ❑ Almost all the time

10. **How often do you have to bend or break a rule or policy in order to carry out an assignment?**

    - ❑ Never
    - ❑ Rarely
    - ❑ Sometimes
    - ❑ Often
    - ❑ Almost all the time

Now we would like you to indicate <u>to what extent</u> you do certain things at work.

1. **To what extent does your job require a great deal of concentration?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

2. **To what extent do you know exactly what is expected of you on your job?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

3. **How much influence do you have over the <u>variety of tasks</u> you do at work?**

   - ❑ None
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

4. **To what extent does your work need your undivided attention?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

5. **In general, to what extent do employees experience very high levels of stress?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

6. **How much influence do you have over the <u>order</u> in which you do tasks at work?**

   - ❑ None
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

7. **To what extent do you have to keep your mind on your work at all times?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

8. **To what extent are there clear, planned goals and objectives for your job?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

9. **How much influence do you have over the <u>amount</u> of work you do?**

   - ❑ None
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

10. **To what extent do you have to concentrate to watch for things going wrong?**

    - ❑ Not at all
    - ❑ Just a little
    - ❑ A moderate amount
    - ❑ Quite a bit
    - ❑ A very great deal

11. To what extent does the way things are run here cause employees unnecessary stress?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

12. How much influence do you have over the pace of your work, that is, how fast or slow you work?

- ❑ None
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

13. To what extent can you let your mind wander and still do your work?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

14. To what extent do you have a clear explanation about what has to be done on your job?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

15. To what extent can you do your work ahead and take a short rest break during work hours?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

16. To what extent do you have to react quickly to prevent problems?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

17. To what extent do some employees have to do more work than others?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

18. In general, how much influence do you have over how you do your work?

- ❑ None
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

19. To what extent do you have to keep track of more than one thing at a time?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

20. To what extent do you know what your job responsibilities are?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

21. To what extent does your job require you to remember many different things?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

Please answer the following questions about <u>your immediate supervisor</u> (boss).

1. To what extent does your immediate supervisor appreciate extra effort from employees?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

2. In general, to what extent does your immediate supervisor ignore employees' suggestions?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

3. To what extent does your immediate supervisor appreciate employees' hard work?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

4. To what extent does your immediate supervisor blame employees for things that are not their fault or are outside their control?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

5. To what extent does your immediate supervisor praise employees for good work?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

6. In general, to what extent does your immediate supervisor understand when an employee is absent due to a personal problem?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

7. To what extent does your immediate supervisor notice if an employee does the best job possible?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

8. **In general, to what extent does your immediate supervisor care about employees' opinions?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

9. **In general, to what extent is your immediate supervisor available to help when an employee has a problem?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

10. **To what extent does your immediate supervisor yell at employees?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

11. **To what extent is your immediate supervisor concerned about employee well-being?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

12. **To what extent does your immediate supervisor care if employees are satisfied with their jobs?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

13. **To what extent does your immediate supervisor lie to employees?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

14. **To what extent does your immediate supervisor treat employees with respect?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

15. **To what extent does your immediate supervisor play favorites?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

16. **In general, to what extent does your immediate supervisor ignore employees' complaints?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

17. **To what extent does your immediate supervisor make unreasonable demands of employees?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

18. **If given the opportunity, to what extent would your immediate supervisor take advantage of employees?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

19. **When making important decisions, to what extent does your immediate supervisor disregard the consequences of these decisions on employees?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

20. **In general, to what extent is your immediate supervisor willing to help employees when they need a special favor?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

21. **To what extent does your immediate supervisor treat employees differently based on their race?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

22. **To what extent does your immediate supervisor care more about making a profit than about employee well-being?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

23. **To what extent is your immediate supervisor concerned about paying employees what they deserve?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

24. **To what extent does your immediate supervisor treat employees like children?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

Now, please answer the following questions about <u>upper management</u>.

1. **To what extent does upper management appreciate extra effort from employees?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

2. **In general, to what extent does upper management ignore employees' suggestions?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

3. **To what extent does upper management appreciate employees' hard work?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

4. **To what extent does upper management blame employees for things that are not their fault or are outside their control?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

5. **To what extent does upper management praise employees for good work?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

6. **In general, to what extent does upper management understand when an employee is absent due to a personal problem?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

7. **To what extent does upper management notice if an employee does the best job possible?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

8. **In general, to what extent does upper management care about employees' opinions?**

   - ❑ Not at all
   - ❑ Just a little
   - ❑ A moderate amount
   - ❑ Quite a bit
   - ❑ A very great deal

9. **In general, to what extent is upper management available to help when an employee has a problem?**

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
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10. **To what extent does upper management yell at employees?**

- ❑ Not at all
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- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

22. To what extent does upper management care more about making a profit than about employee well-being?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

23. If the company earned a greater profit, to what extent would upper management consider increasing employee salaries?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

24. To what extent is upper management concerned about paying employees what they deserve?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
- ❑ A very great deal

25. To what extent does upper management treat employees like children?

- ❑ Not at all
- ❑ Just a little
- ❑ A moderate amount
- ❑ Quite a bit
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The following questions ask about your relationships with people at work. Think about your immediate supervisor (boss).

1. **How much does your boss go out of his way to do things to make your work life easier for you?**

   - ❑ Not at all
   - ❑ A little
   - ❑ Somewhat
   - ❑ Very much

2. **How easy is it to talk with your boss?**

   - ❑ Not at all
   - ❑ A little
   - ❑ Somewhat
   - ❑ Very much

3. **How much can your boss be relied on when things get tough at work?**

   - ❑ Not at all
   - ❑ A little
   - ❑ Somewhat
   - ❑ Very much

4. **How much is your boss willing to listen to your personal problems?**

   - ❑ Not at all
   - ❑ A little
   - ❑ Somewhat
   - ❑ Very much

How about other people at work?

1. **How much do other people at work go out of their way to do things to make your work life easier for you?**

   - ❑ Not at all
   - ❑ A little
   - ❑ Somewhat
   - ❑ Very much

2. **How easy is it to talk with other people at work?**

   - ❑ Not at all
   - ❑ A little
   - ❑ Somewhat
   - ❑ Very much

3. **How much can other people at work be relied on when things get tough at work?**

   - ❑ Not at all
   - ❑ A little
   - ❑ Somewhat
   - ❑ Very much

4. **How much are other people at work willing to listen to your personal problems?**

   - ❑ Not at all
   - ❑ A little
   - ❑ Somewhat
   - ❑ Very much

Your Feelings about Your Job

1. **Knowing what you know now, if you had to decide all over again whether to take the type of job you now have, what would you decide?**

   I would ...
   - ❑ Decide without hesitation to take the same type of job
   - ❑ Have some second thoughts
   - ❑ Decide definitely NOT to take the same type of job

2. **If you were free right now to go into any job you wanted, what would your choice be?**

   I would ...
   - ❑ Take the same job
   - ❑ Take a different job

3. **If a friend of yours told you he was interested in working in a job like yours, what would you tell him?**

   I would ...
   - ❑ Strongly recommend it
   - ❑ Have doubts about recommending it
   - ❑ Advise against it

4. **All in all, how satisfied would you say you are with your job?**

   - ❑ Very satisfied
   - ❑ Somewhat satisfied
   - ❑ Not too satisfied
   - ❑ Not at all satisfied

5. **Have you looked for another job in the last four weeks?**

   - ❑ Yes
   - ❑ No

Please indicate the likelihood of each of the following statements.

1. **How likely is it that, if you want it, you can keep your job for the next year?**

   - ❑ Extremely likely
   - ❑ Very likely
   - ❑ Somewhat likely
   - ❑ A little likely
   - ❑ Not at all likely

2. **If you lost your current job, how likely is it that you could find a comparable job elsewhere?**

   - ❑ Extremely likely
   - ❑ Very likely
   - ❑ Somewhat likely
   - ❑ A little likely
   - ❑ Not at all likely

3. **If you lost your current job, how likely is it that you would be employed elsewhere within a short time?**

   - ❑ Extremely likely
   - ❑ Very likely
   - ❑ Somewhat likely
   - ❑ A little likely
   - ❑ Not at all likely

4. **How likely is it that you will lose your job because of layoffs or downsizing during the next year?**

   - ❑ Extremely likely
   - ❑ Very likely
   - ❑ Somewhat likely
   - ❑ A little likely
   - ❑ Not at all likely

Your Feelings about Your Job

1. **Knowing what you know now, if you had to decide all over again whether to take the type of job you now have, what would you decide?**

   I would ...
   - ❑ Decide without hesitation to take the same type of job
   - ❑ Have some second thoughts
   - ❑ Decide definitely NOT to take the same type of job

2. **If you were free right now to go into any job you wanted, what would your choice be?**

   I would ...
   - ❑ Take the same job
   - ❑ Take a different job

3. **If a friend of yours told you he was interested in working in a job like yours, what would you tell him?**

   I would ...
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   - ❑ Have doubts about recommending it
   - ❑ Advise against it

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   - ❑ Extremely likely
   - ❑ Very likely
   - ❑ Somewhat likely
   - ❑ A little likely
   - ❑ Not at all likely

5. **If your company went out of business, how likely is it that you would have to learn new skills to be employable?**

- ❑ Extremely likely
- ❑ Very likely
- ❑ Somewhat likely
- ❑ A little likely
- ❑ Not at all likely

Think of your job in general. All in all, what is it like most of the time?

1. **Demanding**

- ❑ Yes
- ❑ No
- ❑ I can't decide

2. **Pressured**

- ❑ Yes
- ❑ No
- ❑ I can't decide

3. **Hectic**

- ❑ Yes
- ❑ No
- ❑ I can't decide

4. **Calm**

- ❑ Yes
- ❑ No
- ❑ I can't decide

5. **Relaxed**

- ❑ Yes
- ❑ No
- ❑ I can't decide

6. **Many things stressful**

- ❑ Yes
- ❑ No
- ❑ I can't decide

7. **Pushed**

- ❑ Yes
- ❑ No
- ❑ I can't decide

8. **Irritating**

- ❑ Yes
- ❑ No
- ❑ I can't decide

9. **Under control**

- ❑ Yes
- ❑ No
- ❑ I can't decide

10. **Nerve-wracking**

- ❑ Yes
- ❑ No
- ❑ I can't decide

11. **Hassled**

- ❑ Yes
- ❑ No
- ❑ I can't decide

12. **Comfortable**

- ❑ Yes
- ❑ No
- ❑ I can't decide

About Your Health and Well-Being

We would like to know if you have had any medical complaints, and how your health has been in general, over the past few weeks. Please mark a box for each question.

1. **Over the past few weeks, have you been able to concentrate on whatever you're doing?**

   - ❑ Better than usual
   - ❑ Same as usual
   - ❑ Less than usual
   - ❑ Much less than usual

2. **Over the past few weeks, have you lost much sleep due to worry?**

   - ❑ Not at all
   - ❑ No more than usual
   - ❑ A little more than usual
   - ❑ Much more than usual

3. **Over the past few weeks, have you felt that you are playing a useful part in things?**

   - ❑ More so than usual
   - ❑ Same as usual
   - ❑ Less useful than usual
   - ❑ Much less useful

4. **Over the past few weeks, have you felt capable of making decisions about things?**

   - ❑ More so than usual
   - ❑ Same as usual
   - ❑ Less so than usual
   - ❑ Much less capable

5. **Over the past few weeks, have you felt constantly under strain?**

   - ❑ Not at all
   - ❑ No more than usual
   - ❑ A little more than usual
   - ❑ Much more than usual

6. **Over the past few weeks, have you felt you couldn't overcome your difficulties?**

   - ❑ Not at all
   - ❑ No more than usual
   - ❑ A little more than usual
   - ❑ Much more than usual

7. **Over the past few weeks, have you been able to enjoy your normal day-to-day activities?**

   - ❑ More so than usual
   - ❑ Same as usual
   - ❑ Less so than usual
   - ❑ Much less than usual

8. **Over the past few weeks, have you been able to face up to your problems?**

   - ❑ More so than usual
   - ❑ Same as usual
   - ❑ Less able than usual
   - ❑ Much less able

9. **Over the past few weeks, have you been feeling unhappy and depressed?**

   - ❑ Not at all
   - ❑ No more than usual
   - ❑ A little more than usual
   - ❑ Much more than usual

10. **Over the past few weeks, have you been losing your confidence in yourself?**

    - ❑ Not at all
    - ❑ No more than usual
    - ❑ A little more than usual
    - ❑ Much more than usual

11. Over the past few weeks, have you been thinking of yourself as a worthless person?

- ❑ Not at all
- ❑ No more than usual
- ❑ A little more than usual
- ❑ Much more than usual

12. Over the past few weeks, have you been feeling reasonably happy, all things considered?

- ❑ More so than usual
- ❑ About same as usual
- ❑ Less so than usual
- ❑ Much less than usual

The following questions are about how you have felt, on average, during the past week.

1a. In the past week, how often have you suffered low back and/or buttock pain?

- ❑ None of the time → *Go to Question 2a*
- ❑ A little of the time
- ❑ Some of the time
- ❑ A good bit of the time
- ❑ Most of the time
- ❑ All of the time

1b. How bothersome has the low back and/or buttock pain been?

- ❑ Not at all bothersome
- ❑ Slightly bothersome
- ❑ Somewhat bothersome
- ❑ Moderately bothersome
- ❑ Very bothersome
- ❑ Extremely bothersome

2a. In the past week, how often have you suffered leg pain?

- ❑ None of the time → *Go to Question 3a*
- ❑ A little of the time
- ❑ Some of the time
- ❑ A good bit of the time
- ❑ Most of the time
- ❑ All of the time

2b. How bothersome has the leg pain been?

- ❑ Not all bothersome
- ❑ Slightly bothersome
- ❑ Somewhat bothersome
- ❑ Moderately bothersome
- ❑ Very bothersome
- ❑ Extremely bothersome

3a. In the past week, how often have you suffered numbness or tingling in leg and/or foot?

- ❑ None of the time → *Go to Question 4a*
- ❑ A little of the time
- ❑ Some of the time
- ❑ A good bit of the time
- ❑ Most of the time
- ❑ All of the time

3b. How bothersome has the numbness or tingling in leg and/or foot been?

- ❑ Not at all bothersome
- ❑ Slightly bothersome
- ❑ Somewhat bothersome
- ❑ Moderately bothersome
- ❑ Very bothersome
- ❑ Extremely bothersome

4a. In the past week, how often have you suffered weakness in leg and/or foot?

- ❑ None of the time → *Go to Question 5*
- ❑ A little of the time
- ❑ Some of the time
- ❑ A good bit of the time
- ❑ Most of the time
- ❑ All of the time

4b. How bothersome has the weakness in leg and/or foot been?

- ❑ Not at all bothersome
- ❑ Slightly bothersome
- ❑ Somewhat bothersome
- ❑ Moderately bothersome
- ❑ Very bothersome
- ❑ Extremely bothersome

5. In the past week, how has pain affected you when you get dressed?

- ❑ I can dress myself without pain.
- ❑ I can dress myself without increasing pain.
- ❑ I can dress myself but pain increases.
- ❑ I can dress myself but with significant pain.
- ❑ I can dress myself but with very severe pain.
- ❑ I cannot dress myself due to pain.

6. In the past week, how has pain affected you when you lift something?

- ❑ I can lift heavy objects without pain.
- ❑ I can lift heavy objects but it is painful
- ❑ Pain prevents me from lifting heavy objects off the floor, but I can lift heavy objects if they are on a table.
- ❑ Pain prevents me from lifting heavy objects off the floor, but I can lift light to medium objects if they are on a table.
- ❑ I can only lift light objects due to pain.
- ❑ I cannot lift anything due to pain.

7. In the past week, how has pain affected you when you are walking and running?

- ❑ I can walk or run without pain.
- ❑ I can walk comfortably, but running is painful.
- ❑ Pain prevents me from walking more than 1 hour.
- ❑ Pain prevents me from walking more than 30 minutes.
- ❑ Pain prevents me from walking more than 10 minutes.
- ❑ I am unable to walk or can walk only a few steps at a time.

8. In the past week, how has pain affected you when you are sitting?

- ❑ I can sit in any chair as long as I like.
- ❑ I can only sit in a special chair for as long as I like.
- ❑ Pain prevents me from sitting more than 1 hour.
- ❑ Pain prevents me from sitting more than 30 minutes.
- ❑ Pain prevents me from sitting more than 10 minutes.
- ❑ Pain prevents me from sitting at all.

9. In the past week, how has pain affected you when you are standing?

- ❑ I can stand as long as I want.
- ❑ I can stand as long as I want but it gives me pain.
- ❑ Pain prevents me from standing more than 1 hour.
- ❑ Pain prevents me from standing more than 30 minutes.
- ❑ Pain prevents me from standing more than 10 minutes.
- ❑ Pain prevents me from standing at all.

10. In the past week, how has pain affected you when you sleep?

- ❑ I sleep well.
- ❑ Pain occasionally interrupts my sleep.
- ❑ Pain interrupts my sleep half of the time.
- ❑ Pain often interrupts my sleep.
- ❑ Pain always interrupts my sleep.
- ❑ I never sleep well.

11. In the past week, how has pain affected your social and recreational life?

- ❑ My social and recreational life is unchanged.
- ❑ My social and recreational life is unchanged, but it increases pain.
- ❑ My social and recreational life is unchanged, but it severely increases pain.
- ❑ Pain has restricted my social and recreational life.
- ❑ Pain has severely restricted my social and recreational life.
- ❑ I have essentially no social and recreational life because of pain.

12. In the past week, how has pain affected your traveling?

- ❑ I can travel anywhere.
- ❑ I can travel anywhere but it gives me pain.
- ❑ Pain is bad but I can manage to travel over 2 hours.
- ❑ Pain restricts me to trip of less than 1 hour.
- ❑ Pain restricts me to trip of less than 30 minutes.
- ❑ Pain prevents me from traveling.

13. In the past week, how has pain affected your sex life?

- ❑ My sex life is unchanged.
- ❑ My sex life is unchanged, but causes some pain.
- ❑ My sex life is nearly unchanged, but it is very painful.
- ❑ My sex life is severely restricted by pain.
- ❑ My sex life is nearly absent because of pain.
- ❑ Pain prevents any sex life at all.

14. During the past year, did you seek medical care for back pain?

- ❑ No
- ❑ Yes
  Where did you go?

  _____

  What treatment did you receive?

  _____

15. During the past year, did you lose work days due to back pain?

- ❑ No
- ❑ Yes

How many days did you lose in the last year?

_____days

About Yourself

1. What is your birth date?

_____/_____/_____
Month Day Year

2. Are you male or female?

- ❑ Male
- ❑ Female

3. Your height:

_____feet _____inches

4. Your weight

_____pounds

5. Which hand is your dominant hand?

- ❑ Right-handed
- ❑ Left-handed
- ❑ Both

6. Do you currently smoke?

- ❑ No
- ❑ Yes

How many cigarettes do you smoke per day? (One pack = 20 cigarettes)

- ❑ 10 cigarettes or less
- ❑ 11 – 20
- ❑ 21 – 30
- ❑ 31 or more

7. What is the highest level of education you have completed?

- ❑ Less than a high school diploma
- ❑ High school diploma
- ❑ Some college or vocational training
- ❑ 2-year college degree
- ❑ 4-year college degree or higher

8. Which of the following best describes your present marital status?

- ❑ Never married, currently single
- ❑ Never married, currently have a partner
- ❑ Married
- ❑ Separated
- ❑ Divorced
- ❑ Widowed

9. How many children do you have?

.

- ❑ **I have _____ children.**

What are the ages of your children in years? (Write "0" if less than 1 year old.)

_____ _____ _____ _____ _____

Please circle the age of children who live with you.

APPENDIX A-3

Correlation matrix for psychosocial work characteristics,
global job attitudes, employee well-being, and LBP outcomes

A-3 Correlation matrix for psychosocial job characteristics, global job attitudes, and employee well-being

Table A-3 is a correlation matrix of psychosocial work characteristics, global job attitudes and well-being, and LBP outcome variables, calculated for the 305 participants who provided both baseline and follow-up data. Correlation coefficients below the diagonal are for baseline measure and the correlations above the diagonal are for follow-up measures. The diagonal elements indicate stability coefficients. Correlation coefficients with NASS Neurogenic Symptoms Scale and Pain and Disability Scale are Spearman's r (non-parametric) because of the highly skewed distribution in these two variables.

Table A-3. Correlations of outcomes with psychosocial job characteristics (n=305)

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Independent variable																			
1	Workload	**0.58**	0.54	0.06	0.34	0.20	0.08	-0.11	-0.28	-0.10	0.29	0.29	0.18	-0.36	0.61	0.24	0.05	0.22	0.29
2	Role conflict	0.54	**0.57**	0.30	0.11	0.18	0.09	-0.13	-0.42	-0.10	0.54	0.53	0.20	-0.45	0.56	0.39	0.01	0.32	0.32
3	Role ambiguity	0.04	0.18	**0.57**	-0.35	0.22	0.08	-0.40	-0.38	-0.14	0.41	0.38	0.21	-0.24	0.16	0.23	0.01	0.12	0.15
4	Mental demands	0.36	0.18	-0.34	**0.64**	0.07	-0.02	0.17	0.07	0.06	-0.06	-0.09	-0.10	0.04	0.23	-0.09	0.03	0.00	-0.02
5	Job insecurity	0.03	0.14	0.23	0.00	**0.40**	0.27	-0.06	-0.19	-0.15	0.21	0.31	0.31	-0.29	0.26	0.27	0.11	0.14	0.18
6	Employment insecurity	-0.06	0.02	0.12	-0.11	0.21	**0.59**	-0.03	-0.04	-0.08	0.07	0.01	0.09	-0.11	0.06	0.14	-0.07	0.09	0.03
7	Job control	-0.05	-0.02	-0.41	0.21	-0.13	-0.10	**0.56**	0.23	0.00	-0.25	-0.27	-0.13	0.20	-0.22	-0.19	-0.03	-0.12	-0.21
8	Social support (Supervisor)	-0.17	-0.37	-0.29	0.11	-0.20	-0.06	0.21	**0.66**	0.27	-0.78	-0.55	-0.38	0.34	-0.43	-0.25	0.01	-0.14	-0.20
9	Social support (Coworker)	-0.15	-0.23	-0.21	0.04	-0.07	-0.10	0.05	0.33	**0.51**	-0.18	-0.15	-0.16	0.05	-0.13	-0.17	0.10	-0.06	-0.04
10	Unfairness (Supervisor)	0.26	0.51	0.35	-0.03	0.28	0.05	-0.25	-0.78	-0.24	**0.75**	0.62	0.33	-0.41	0.47	0.29	0.05	0.20	0.23
11	Unfairness (Management)	0.25	0.49	0.29	0.06	0.37	0.06	-0.21	-0.53	-0.24	0.65	**0.75**	0.58	-0.49	0.53	0.32	0.07	0.24	0.25
12	Unfairness (Wages)	0.22	0.23	0.18	0.07	0.27	0.16	-0.23	-0.34	-0.18	0.37	0.62	**0.62**	-0.43	0.36	0.19	0.03	0.08	0.18
13	Job satisfaction	-0.28	-0.41	-0.20	-0.05	-0.27	-0.14	0.15	0.37	0.20	-0.44	-0.52	-0.40	**0.63**	-0.51	-0.41	-0.10	-0.18	-0.28
14	Job strain	0.60	0.57	0.11	0.24	0.11	0.07	-0.15	-0.40	-0.23	0.49	0.54	0.38	-0.53	**0.74**	0.42	0.07	0.30	0.32
15	Psychological well-being	0.26	0.46	0.16	0.00	0.24	0.05	-0.06	-0.27	-0.20	0.35	0.44	0.24	-0.44	0.44	**0.54**	0.00	0.31	0.36
Outcome variable																			
16	LMM %Normal	-0.07	-0.05	0.01	-0.02	0.16	-0.06	0.01	0.05	0.18	-0.05	-0.01	0.06	-0.02	-0.02	-0.05	**0.60**	-0.07	-0.07
17	Neurogenic Symptoms	0.19	0.37	0.15	0.02	0.12	0.04	-0.05	-0.18	-0.11	0.30	0.29	0.10	-0.30	0.28	0.37	-0.12	**0.65**	0.63
18	Pain and Disability	0.23	0.42	0.05	-0.03	0.13	-0.01	-0.03	-0.22	-0.13	0.27	0.28	0.12	-0.29	0.31	0.35	-0.21	0.64	**0.69**

Notes. Correlation coefficients below the diagonal are for baseline, above the diagonal are for follow-up. The diagonal values indicate stability coefficients. Nonparametric correlation coefficients are reported when one or both variables are self-report LBP symptom measures are. $|r| > .11$, $p<.05$; if $|r| > .15$, $p<.01$.

APPENDIX A-4

Correlation matrix for physical demands measures and LBP outcome measures

A-4 Correlation matrix for physical demands measures and LBP outcome measures

Table A-4 presents correlation coefficients between physical demand measures and LBP outcome measures. Since both physical demand measures and self-report symptom measures were highly skewed, nonparametric correlation coefficients are reported.

Table A-4. Correlations of outcomes with physical demands variables

	Baseline (all)			Baseline (panel)			Follow-up (panel)		
Variable	LMM % Normal	Neurogenic Symptoms	Pain & Disability	LMM % Normal	Neurogenic Symptoms	Pain & Disability	LMM % Normal	Neurogenic Symptoms	Pain & Disability
Global:									
Total # of Exertions/hour	0.074	0.036	-0.073	0.086	0.044	-0.054	0.089	0.044	-0.030
Number above TLV	0.068	0.065	-0.047	0.068	0.086	-0.020	0.058	0.079	0.014
Total % above TLV	0.055	0.054	-0.019	0.047	0.091	0.008	0.034	**0.114**	0.052
Moment Arm Regions:									
Close: Total # of Exertions/hour	**0.115**	0.031	-0.091	0.103	0.039	-0.068	0.098	0.050	-0.039
Close: Number above TLV	0.060	0.052	-0.074	0.067	0.071	-0.077	0.097	**0.115**	-0.048
Close: % above TLV	0.045	0.067	-0.033	0.062	0.090	-0.031	0.104	**0.134**	-0.006
Intermediate: Total # of Exertions/hour	0.090	0.027	-0.081	0.076	0.031	-0.051	0.079	0.031	-0.026
Intermediate: Number above TLV	0.076	0.072	-0.031	0.058	0.096	0.010	0.044	0.081	0.032
Intermediate: % above TLV	0.086	0.078	0.002	0.052	**0.122**	0.042	0.021	**0.130**	0.080
Far: Total # of Exertions/hour	0.084	0.030	-0.086	0.078	0.031	-0.071	0.090	0.041	-0.037
Far: Number above TLV	0.093	0.066	-0.036	0.079	0.071	-0.011	0.088	0.087	0.016
Far: % above TLV	**0.101**	0.092	0.044	0.069	0.084	0.069	0.059	**0.139**	0.086
Height Regions:									
Shoulder: # of Exertions/hour	0.016	0.001	-0.033	0.015	0.026	0.007	0.075	0.012	0.022
Shoulder: Number Above TLV	0.028	0.017	-0.048	0.030	0.046	-0.016	0.055	0.042	0.034
Shoulder: % above TLV	0.039	0.033	-0.024	0.022	0.061	0.010	0.063	0.055	0.051
Knuckle to Shoulder: # of Exertions/hour	**0.113**	0.044	-0.061	0.110	0.042	-0.037	**0.115**	0.047	0.015
Knuckle to Shoulder: Number Above TLV	**0.114**	0.084	-0.026	0.100	0.102	-0.006	0.084	0.096	0.042
Knuckle to Shoulder: % above TLV	0.094	0.054	-0.012	0.069	0.083	0.007	0.034	0.089	0.052
Mid Shin to Knuckle: # of Exertions/hour	0.042	0.020	-0.044	0.001	0.059	-0.027	0.032	0.046	-0.022
Mid Shin to Knuckle: Number Above TLV	0.076	-0.009	-0.037	-0.005	0.039	0.004	0.029	0.083	0.027
Mid Shin to Knuckle: % above TLV	0.081	-0.005	-0.006	0.028	0.022	0.039	-0.020	0.069	0.071
Floor to Mid Shin: # of Exertions/hour	**-0.105**	-0.033	-0.002	-0.098	0.005	0.040	-0.037	0.094	0.034
Floor to Mid Shin: Number Above TLV	**-0.102**	-0.039	-0.014	-0.097	0.002	0.030	-0.036	0.084	0.023
Floor to Mid Shin: % above TLV	**-0.128**	-0.014	0.024	**-0.119**	0.024	0.066	-0.061	**0.124**	0.071

Note: Bold indicates $p<.05$

Table A-4 (Continued)

	Baseline (all)			Baseline (panel)			Follow-up (panel)		
Variable	LMM % Normal	Neurogenic Symptoms	Pain & Disability	LMM % Normal	Neurogenic Symptoms	Pain & Disability	LMM % Normal	Neurogenic Symptoms	Pain & Disability
Combine Moment Arm and Height Regions:									
Combine Moment Arm and Height Regions:									
Shoulder-Close: # of Exertions/hour	0.035	-0.009	-0.051	0.048	0.019	-0.021	0.066	-0.003	0.003
Shoulder-Close: Number Above TLV	0.092	0.050	-0.029	0.108	0.096	-0.015	0.078	0.065	0.049
Shoulder-Close: % above TLV	**0.105**	0.042	-0.019	0.108	0.088	-0.007	0.074	0.064	0.056
Shoulder-Intermediate: Total # of exertions	0.012	-0.029	-0.057	0.004	0.010	-0.023	0.058	-0.003	-0.001
Shoulder-Intermediate: # above TLV	0.024	-0.018	-0.072	0.019	0.006	-0.044	0.035	0.024	0.011
Shoulder-Intermediate: % above TLV	0.040	-0.016	-0.061	0.019	0.009	-0.030	0.037	0.046	0.025
Shoulder - Far: Total # of exertions	-0.072	0.034	-0.035	-0.050	0.057	-0.007	0.030	0.059	0.004
Shoulder - Far: # above TLV	-0.072	0.034	-0.035	-0.050	0.057	-0.007	0.030	0.059	0.004
Shoulder - Far: : % above TLV	-0.066	0.029	-0.029	-0.053	0.055	-0.003	0.034	0.073	0.020
Knuckle/Shoulder-Clos:Total # of exertions	**0.128**	0.046	-0.072	**0.125**	0.050	-0.046	0.112	0.040	0.004
Knuckle/Shoulder-Clos:# above TLV	0.071	0.073	-0.033	0.067	0.092	-0.032	0.051	0.109	-0.006
Knuckle/Shoulder-Clos: % above TLV	0.058	0.092	-0.007	0.052	**0.128**	0.011	0.045	**0.122**	0.019
Knuckle/Shoulder-Inte Total # of exertions	**0.106**	0.045	-0.052	0.102	0.044	-0.020	0.098	0.038	0.023
Knuckle/Shoulder-Inte: # above TLV	0.096	0.103	0.006	0.078	**0.130**	0.043	0.054	0.100	0.069
Knuckle/Shoulder-Inte: % above TLV	0.094	0.095	0.031	0.066	**0.127**	0.060	0.049	**0.125**	0.083
Knuckle/Shoulder-Far: Total # of exertions	**0.107**	0.039	-0.065	0.104	0.038	-0.043	0.104	0.041	0.005
Knuckle/Shoulder-Far: # above TLV	**0.124**	0.080	-0.025	**0.112**	0.083	-0.010	0.085	0.094	0.043
Knuckle/Shoulder-Far: % above TLV	**0.106**	**0.105**	0.021	0.084	0.091	0.018	0.075	**0.125**	0.070
Midshin/Knuckle-Close Total # of exertions	-0.007	-0.026	-0.043	-0.010	0.005	-0.051	-0.006	0.051	-0.053
Midshin/Knuckle-Close: # above TLV	0.026	-0.035	-0.038	0.004	0.019	-0.033	0.067	0.089	-0.033
Midshin/Knuckle-Close: % above TLV	0.037	-0.052	-0.033	0.018	0.049	-0.030	0.064	0.077	-0.023
Midshin/knuckle - Int Total # of exertions	0.051	0.037	-0.056	0.008	0.087	-0.023	0.018	0.051	-0.011
Midshin/knuckle – Int: # above TLV	0.082	0.001	-0.042	0.008	0.054	0.013	0.021	0.061	0.031
Midshin/knuckle - Int: % above TLV	**0.109**	-0.014	-0.020	0.053	0.015	0.019	-0.014	0.075	0.069
Midshin/knuckle - Far Total # of exertions	0.040	0.006	-0.064	0.033	0.028	-0.074	0.045	0.067	-0.064
Midshin/knuckle – Far: # above TLV	0.012	0.022	-0.019	-0.017	0.041	-0.024	0.038	**0.115**	-0.025
Midshin/knuckle – Far: % above TLV	0.007	0.035	0.011	-0.021	0.042	0.002	0.032	**0.124**	-0.002

Note. Bold indicates p<.05

Table A-4 (Continued)

	Baseline (all)			Baseline (panel)			Follow-up (panel)		
Variable	LMM % Normal	Neurogenic Symptoms	Pain & Disability	LMM % Normal	Neurogenic Symptoms	Pain & Disability	LMM % Normal	Neurogenic Symptoms	Pain & Disability
Combine Moment Arm and Height Regions:									
Floor - Close: Total # of exertions	-0.039	-0.063	-0.050	-0.046	0.026	-0.012	-0.002	0.055	-0.021
Floor - Close: # above TLV	-0.048	-0.007	-0.055	-0.060	0.023	-0.042	0.011	**0.115**	-0.034
Floor - Close: % above TLV	-0.039	0.007	-0.040	-0.054	0.038	-0.027	0.001	**0.132**	-0.016
Floor - Intermediate: Total # of exertions	**-0.120**	-0.024	0.006	-0.109	0.011	0.042	-0.040	0.091	0.035
Floor - Intermediate: # above TLV	**-0.120**	-0.024	0.006	-0.109	0.011	0.042	-0.040	0.091	0.035
Floor - Intermediate: % above TLV	**-0.123**	-0.001	0.029	-0.109	0.035	0.065	-0.055	**0.135**	0.080
Floor - Far: Total # of exertions	-0.044	-0.033	-0.015	-0.054	0.006	0.019	0.008	0.090	-0.009
Floor - Far: # above TLV	-0.044	-0.033	-0.015	-0.054	0.006	0.019	0.008	0.090	-0.009
Floor - Far: % above TLV	-0.032	-0.029	0.009	-0.047	0.004	0.049	-0.003	0.102	0.021

Notes. Bold indicates p>.05

APPENDIX A-5

List of Personal Characteristics

A-5 List of personal characteristics offered to CART

Age
Height
Weight
Gender
Spanish version
Race
Marital status
Education
Handedness
Smoking status
Children
Second job
Job tenure company
Job tenure job
Job tenure manual material handling

APPENDIX A-6

One-way ANOVAs with change in pain and disability as the grouping variable

A-6. One-way ANOVAs with change in pain and disability as the grouping variable

Personal characteristics		N	Mean	Std. Deviation	Minimum	Maximum
age	stayed non-symptomatic	67	36.3731	10.59994	19.00	58.00
	got better	63	36.6032	11.62525	19.00	63.00
	stayed mild/mod symptoms	84	38.7738	12.32428	18.00	73.00
	got worse	52	35.4231	11.88564	19.00	64.00
ns	stayed highly symptomatic	37	36.6486	12.39672	22.00	77.00
	Total	303	36.9571	11.73274	18.00	77.00
Spanish survey	stayed non-symptomatic	67	.16	.373	0	1
	got better	63	.13	.336	0	1
P=.045	stayed mild/mod symptoms	84	.06	.238	0	1
	got worse	52	.13	.345	0	1
	stayed highly symptomatic	37	.00	.000	0	0
	Total	303	.10	.304	0	1
CHBMI	stayed non-symptomatic	64	27.2463	4.86552	18.88	39.58
	got better	60	28.6663	4.94469	18.26	40.72
P=.197	stayed mild/mod symptoms	82	28.0392	4.98454	20.67	44.42
	got worse	51	26.4747	4.64902	18.61	40.68
	stayed highly symptomatic	35	27.6390	6.19707	18.60	48.25
	Total	292	27.6730	5.07266	18.26	48.25
Personal characteristics are not strongly associated with the pain and disability outcome.						
Physical Job Demands						
Global: Total # of Exertions/hour	stayed non-symptomatic	66	170.8909	198.6981	.00	993.00
	got better	63	112.2317	118.9187	1.00	554.00
	stayed mild/mod symptoms	83	89.8133	96.94293	1.00	552.00
P=.008	got worse	50	140.2760	131.2784	1.00	554.00
	stayed highly symptomatic	37	148.3784	149.0861	1.00	554.00
	Total	299	128.1194	143.5330	.00	993.00
Global: Number above TLV	stayed non-symptomatic	66	78.2621	84.77575	.00	371.00
P=.010	got better	63	63.0921	78.89176	.00	371.00

	stayed mild/mod symptoms	83	48.8464	70.69137	.00	387.00
	got worse	50	91.9810	94.60523	.00	387.00
	stayed highly symptomatic	37	98.0338	105.6601	.00	387.00
	Total	299	71.6410	85.92872	.00	387.00
Moment Arm Regions: Far: Total # of Exertions/hour	stayed non-symptomatic	66	35.0971	41.30456	.00	170.00
	got better	63	23.1608	29.37122	.00	135.00
P=.012	stayed mild/mod symptoms	83	17.2674	22.69366	.00	134.00
	got worse	50	28.9992	32.25400	.00	135.00
	stayed highly symptomatic	37	31.0843	37.29762	.00	135.00
	Total	299	26.1164	32.83920	.00	170.00
Moment Arm Regions: Far: Number above TLV	stayed non-symptomatic	66	22.2983	28.15969	.00	135.00
	got better	63	17.6479	26.37024	.00	135.00
	stayed mild/mod symptoms	83	13.2034	22.44490	.00	134.00
P=.022	got worse	50	25.9238	32.71955	.00	135.00
	stayed highly symptomatic	37	29.3468	38.18242	.00	135.00
	Total	299	20.2723	28.98766	.00	135.00
Combine Moment Arm and Height Regions: Knuckle/Shoulder-Inter: Number above TLV	stayed non-symptomatic	66	32.3444	45.45658	.00	189.00
	got better	63	25.9752	41.10752	.00	189.00
	stayed mild/mod symptoms	83	19.8149	36.72971	.00	193.00
P=.022	got worse	50	38.5206	49.21826	.00	193.00
	stayed highly symptomatic	37	46.0422	56.53482	.00	193.00
	Total	299	30.2522	45.11697	.00	193.00
Combine Moment Arm and Height Regions: Knuckle/Shoulder-Far: Total # of Exertions/hour	stayed non-symptomatic	66	24.8958	30.03193	.00	135.00
	got better	63	18.5921	26.67900	.00	135.00
	stayed mild/mod symptoms	83	14.5033	22.07864	.00	134.00
	got worse	50	25.2980	32.84304	.00	135.00
P=.052	stayed highly symptomatic	37	28.7865	38.17163	.00	135.00

	Total	299	21.2314	29.31299	.00	135.00
Combine Moment Arm and Height Regions: Knuckle/Shoulder-Far: Number above TLV	stayed non-symptomatic	66	18.2413	28.48709	.00	135.00
	got better	63	14.0127	26.58341	.00	135.00
	stayed mild/mod symptoms	83	10.9078	22.44104	.00	134.00
P=.029	got worse	50	22.6460	33.52951	.00	135.00
	stayed highly symptomatic	37	27.2432	39.02308	.00	135.00
	Total	299	17.1651	29.36566	.00	135.00

The physical job demands were all associated with changes in pain and disability. The pattern of means seems to indicate both a healthy worker effect and a causal effect. The groups with the most exertions tended to be those who were highly symptomatic, those who got worse, and those who were non-symptomatic. The former two groups may indicate an effect of job demands on the outcome. The latter groups probably indicates a "healthy back group" who are having no problem with heavy exertion.

Psychosocial work characteristics						
Role conflict	stayed non-symptomatic	67	1.9348	.58538	1.00	3.33
	got better	62	2.4769	.80186	1.33	4.83
	stayed mild/mod symptoms	84	2.3726	.60403	1.17	4.33
P<.001	got worse	52	2.3612	.57661	1.17	3.67
	stayed highly symptomatic	37	2.8153	.69030	1.83	4.33
	Total	302	2.3492	.69845	1.00	4.83
Mental demands	stayed non-symptomatic	67	3.5434	.61350	2.25	4.75
	got better	62	3.5749	.64256	2.00	4.88
	stayed mild/mod symptoms	84	3.6667	.60939	2.00	4.75
ns	got worse	52	3.5553	.60452	2.38	4.75
	stayed highly symptomatic	37	3.6250	.63465	2.13	4.50
	Total	302	3.5962	.61740	2.00	4.88
Job control	stayed non-symptomatic	66	3.1995	.86490	1.17	5.00
	got better	62	3.2487	.73342	1.33	4.50
	stayed mild/mod symptoms	84	3.2643	.73227	1.00	4.83
ns	got worse	52	3.1282	.74945	1.17	4.83
	stayed highly symptomatic	37	3.0721	.85846	1.00	4.67
	Total	301	3.1997	.77992	1.00	5.00
Social support (boss)	stayed non-symptomatic	64	3.2331	.70604	1.00	4.00
	got better	63	2.8452	.88380	1.00	4.00

	stayed mild/mod symptoms	84	2.8884	.66852	1.25	4.00
	got worse	51	2.6912	.77393	1.25	4.00
P=.001	stayed highly symptomatic	37	2.6689	.84585	1.00	4.00
	Total	299	2.8923	.78603	1.00	4.00
Social support (coworkers)	stayed non-symptomatic	66	3.1326	.56025	2.00	4.00
	got better	63	2.9365	.64284	1.00	4.00
	stayed mild/mod symptoms	84	2.9043	.60932	1.00	4.00
	got worse	52	2.7788	.56805	1.25	3.75
P=.029	stayed highly symptomatic	37	2.9527	.59172	1.25	4.00
	Total	302	2.9452	.60398	1.00	4.00
Unfairness (boss)	stayed non-symptomatic	61	2.0190	.70351	1.00	4.63
	got better	61	2.5940	.85595	1.00	5.00
	stayed mild/mod symptoms	82	2.5138	.69307	1.21	4.84
	got worse	47	2.5375	.79857	1.16	4.11
P<.001	stayed highly symptomatic	36	2.7222	.89731	1.05	4.95
	Total	287	2.4557	.80650	1.00	5.00
Unfairness (management)	stayed non-symptomatic	59	2.3991	.82290	1.05	4.71
	got better	61	2.6881	.88959	1.00	5.00
	stayed mild/mod symptoms	80	2.7182	.70460	1.10	4.67
P<.001	got worse	46	2.6817	.74413	1.48	4.38
	stayed highly symptomatic	33	3.2107	.69641	1.95	4.86
	Total	279	2.6964	.80558	1.00	5.00
Job satisfaction	stayed non-symptomatic	64	1.7230	.26929	1.13	2.00
	got better	63	1.6383	.27749	1.00	2.00
	stayed mild/mod symptoms	83	1.5968	.26567	1.00	2.00
	got worse	52	1.5639	.27234	1.00	2.00
P<.001	stayed highly symptomatic	37	1.4528	.30332	1.00	2.00
	Total	299	1.6090	.28457	1.00	2.00
Global job strain (Stress-In-General)	stayed non-symptomatic	66	.9153	.79904	.00	3.00
	got better	61	1.3586	.98939	.00	3.00
	stayed mild/mod symptoms	83	1.6446	.76770	.00	3.00
P<.001	got worse	52	1.2982	.79550	.00	3.00

	stayed highly symptomatic	37	1.9054	.91922	.00	3.00
	Total	299	1.3973	.90082	.00	3.00

Almost all of the psychosocial work characteristics show the same pattern. Those employees who stayed non-symptomatic have the best psychosocial characteristics and those who stayed highly symptomatic have the worst. The other 3 groups are in the middle. Coworker support shows a slightly different pattern. Non-symptomatic employees report the most support, but the highly symptomatic employees report the next highest support. Those who got worse report having the least cowoker support. It could be that in the non-symptomatic group, coworker support is playing a preventive role. In the highly symptomatic group, it could be activated by need of the employees. But of course this is just a post-hoc explanation.

APPENDIX A-7

One-way ANOVAs with change in neurgenic symptoms as the grouping variable

A-7 One-way ANOVAs using change in neurogenic symptoms as the grouping variable

Variable		N	Mean	Std. Deviation	Minimum	Maximum
Combine Moment Arm and Height Regions: Knuckle/Shoulder-Inter: Number above TLV	Got worse	39	39.0996	55.14725	.00	193.00
	stayed nonsymptomatic	104	29.1499	44.68011	.00	189.00
P=.116	Got better	76	28.8778	40.46057	.00	189.00
	stayed mild to mod symptoms	51	19.9235	30.39337	.00	129.00
	stayed highly symptomatic	28	45.2541	61.16218	.00	189.00
	Total	298	30.3168	45.17901	.00	193.00
age	Got worse	40	32.5500	10.94965	18.00	61.00
	stayed nonsymptomatic	106	37.1981	11.11020	19.00	64.00
P=.138	Got better	76	38.1447	10.75386	19.00	63.00
	stayed mild to mod symptoms	52	38.0385	13.91284	20.00	73.00
	stayed highly symptomatic	28	37.4643	12.66808	22.00	77.00
	Total	302	36.9901	11.73814	18.00	77.00
Social support (boss)	Got worse	40	2.5500	.71208	1.25	4.00
	stayed nonsymptomatic	104	3.2095	.67654	1.00	4.00
P<.001	Got better	75	2.7100	.84133	1.00	4.00
	stayed mild to mod symptoms	52	2.9135	.73245	1.25	4.00
	stayed highly symptomatic	28	2.6518	.82028	1.00	4.00
	Total	299	2.8923	.78603	1.00	4.00
Social support (coworkers)	Got worse	40	2.7188	.70753	1.25	4.00
	stayed nonsymptomatic	105	3.1321	.50947	1.75	4.00
P<.001	Got better	76	2.8695	.65026	1.00	4.00
	stayed mild to mod symptoms	52	2.8125	.55544	1.00	3.75
	stayed highly symptomatic	28	3.0536	.52861	2.00	4.00
	Total	301	2.9484	.60252	1.00	4.00
Unfairness (boss)	Got worse	38	2.6468	.76534	1.21	4.84
	stayed nonsymptomatic	101	2.1066	.69306	1.00	4.63

P<.001	Got better	71	2.7135	.83271	1.00	5.00
	stayed mild to mod symptoms	49	2.4640	.74033	1.21	4.11
	stayed highly symptomatic	28	2.7876	.86000	1.26	4.95
	Total	287	2.4557	.80650	1.00	5.00
Unfairness (management)	Got worse	35	2.9701	.74079	1.48	4.67
	stayed nonsymptomatic	98	2.3554	.71169	1.05	4.38
	Got better	72	2.9074	.85748	1.00	5.00
P<.001	stayed mild to mod symptoms	49	2.6837	.64867	1.10	4.00
	stayed highly symptomatic	25	3.0667	.90288	1.33	4.86
	Total	279	2.6964	.80558	1.00	5.00
Job satisfaction	Got worse	40	1.5386	.27188	1.00	2.00
	stayed nonsymptomatic	103	1.7095	.24848	1.17	2.00
P<.001	Got better	76	1.5789	.29520	1.00	2.00
	stayed mild to mod symptoms	52	1.5778	.28533	1.00	2.00
	stayed highly symptomatic	27	1.4683	.29979	1.00	2.00
	Total	298	1.6084	.28485	1.00	2.00
Body Mass Index	Got worse	39	26.7032	4.47385	21.02	40.72
	stayed nonsymptomatic	104	27.3972	4.45891	18.88	39.58
P=.227	Got better	74	28.7623	5.73349	18.26	44.42
	stayed mild to mod symptoms	48	27.2061	5.09281	18.60	40.68
	stayed highly symptomatic	27	27.9813	5.93355	20.92	48.25
	Total	292	27.6730	5.07266	18.26	48.25
Global: Number above TLV	Got worse	39	90.4167	107.94306	.00	387.00
	stayed nonsymptomatic	104	66.7365	83.58566	.00	371.00
P=.179	Got better	76	69.1158	76.91733	.00	371.00
	stayed mild to mod symptoms	51	55.4608	58.65201	.00	257.00
	stayed highly symptomatic	28	95.6607	115.63655	.00	371.00
	Total	298	71.2304	85.77894	.00	387.00